Rangeland Area and Condition

Cattle grazing in annual grassland and blue oak woodland rangelands.

Rangelands, as defined by the State of California's Public Resource Code 4789, means lands on which existing vegetation, whether growing naturally or through management, is suitable for grazing or browsing of domestic livestock for at least a portion of the year. Rangelands cover a variety of ecological regions characterized by the presence of native plant communities. In these communities, management by ecological means rather than agronomic means is most prominent. Rangeland vegetation types include any natural grasslands, savannas, shrublands, deserts, wetlands, or woodlands that support a vegetative cover of native grasses, grass-like plants, forbs, shrubs, and naturalized species. Rangelands can also include forested land that possesses grazing resources, although these habitats are essentially transient as grazing and are often significant when tree cover has temporarily been reduced through fire or harvest.

Rangelands are unique in that they are the largest resource use designation in the State. They are often used for complimentary and competing uses such as domestic livestock grazing and for wildlife habitat. From a domestic livestock grazing perspective, these lands provide low revenues and usually require low investments and management costs. However, rangelands provide many social benefits at minimum cost to nearby residents because of the their vast extent and often their proximity to metropolitan areas. The competing and complimentary uses also can mean potential problems to social assets such as maintaining open space, streams, soil, and wildlife habitats. Because of these competing uses, vast extent, and proximity to nearby metropolitan areas, management challenges include protecting, monitoring conditions, and restoring rangeland in a cost effective manner.

This assessment of range area and condition is derived from two Montreal Process Criterion: Criterion 2, Maintenance of productive capacity of forest and rangelands resources and Criterion 3, Maintenance of forest and range ecosystem health and vitality. Information on these criteria is included in three distinct categories of analysis:

- rangeland area;
- forage production to support grazing; and
- rangeland condition assessment.

While this assessment of rangeland condition overlaps with other criterion (Maintenance of soil and water resources), the primary purpose is to review the significant factors that affect rangeland productivity related to forage grazing.

The major topics reviewed in the context of rangeland area include measurement of both the total rangeland area and the area actually grazed, and the changing land base of rangelands. Forage production focuses on the traditional review of rangeland forage production and use of rangelands by livestock and wildlife for foraging. Rangeland condition assessment discusses traditional vegetation succession descriptions as well as modern evaluations. These include state/transition models and factors demonstrating health such as soil and water conditions, woodland expansion, and spread of exotic plants.

Findings on rangeland area

Rangeland extent

The area of primary rangelands, excluding upland forests, covers over 57 percent of the State.

Identifying the specific land covers most important to grazing (referred to as primary rangelands) provides a broad estimate of rangelands (see California Rangelands) and is the method used by Dr. Mel George of the University of California, Davis (George, 2002). After identification, the area is calculated (Table 1) using the most recent land cover mapping information compiled by the Fire and Resource Assessment Program (FRAP). Additionally, all primary rangelands are classified using the California Wildlife Habitat Relationship (CWHR) system (see CWHR and Methods). This method of identifying the primary rangeland area gives an estimate of the potential rangeland base, not necessarily the lands being used.

In California, there are substantial areas of forest land particularly within the U.S. Forest Service (USFS) grazing allotments. Though these allotments are often used for grazing, they are not shown in the estimate because forage output is transient, often only related to areas with little tree cover following harvesting or fire. These lands are termed secondary rangeland and limited information on grazing activities and other measures related to condition are provided.

Table 1. Area of primary rangeland by ownership and CWHR type (thousand acres)

Habitat type	Private	USFS	BLM	NPS	Other public	Total
Conifer Woodland						
Juniper	339	317	234	66	59	1,015
Pinyon-Juniper	119	734	249	154	92	1,348
Total	458	1,051	482	220	151	2,363
Hardwood Woodland						
Blue Oak-Foothill Pine	754	39	121	17	49	979
Blue Oak Woodland	2,457	129	104	9	120	2,819
Coastal Oak Woodland	832	138	12	8	104	1,095
Eucalyptus	9	(L)	(L)	(L)	1	11
Valley Foothill Riparian	114	4	2	1	27	147
Valley Oak Woodland	126	1	2	(L)	9	137
Total	4,292	310	239	36	309	5,188
Hardwood Forest						
Montane Riparian	100	40	1	43	27	211
Shrub						
Alpine Dwarf Shrub	1	201	(L)	18	(L)	219
Bitterbrush	81	162	25	26	5	299
Chamise-Redshank Chaparral	671	399	187	12	114	1,383
Coastal Scrub	1,175	218	74	28	235	1,730
Low Sagebrush	19	151	48	1	11	230
Mixed Chaparral	1,813	2,152	457	16	301	4,739
Montane Chaparral	369	1,032	23	43	14	1,481
Sagebrush	880	1,347	1,407	168	174	3,976
Unknown Shrub	426	12	40	8	24	509
Total	5,433	5,673	2,261	319	878	14,565
Grasslands						
Annual Grassland	9,592	233	496	38	494	10,852
Perennial Grassland	30	(L)	(L)	4	32	67
Total	9,621	233	496	43	526	10,919
Desert Shrub						
Alkali Desert Scrub	630	70	1,184	470	648	3,003
Desert Riparian	15		18	3	11	47
Desert Scrub	3,348	126	8,326	4,136	3,099	19,036
Desert Succulent Shrub	115		216	17	156	503
Desert Wash	164	(L)	471	33	204	872
Total	4,272	197	10,216	4,659	4,117	23,461
Desert Woodland						
Joshua Tree	27	3	34	18	2	84
Palm Desert	(L)		3		(L)	3
Total	27	3	37	18	2	87
Wetland						
Wet Meadow	145	69	11	20	23	268
Grand total	24,350	7,577	13,743	5,359	6,034	57,062

BLM – U.S. Bureau of Land Management; (L) – less than 500 acres; NPS – National Park Service; USFS – U.S. Forest Service

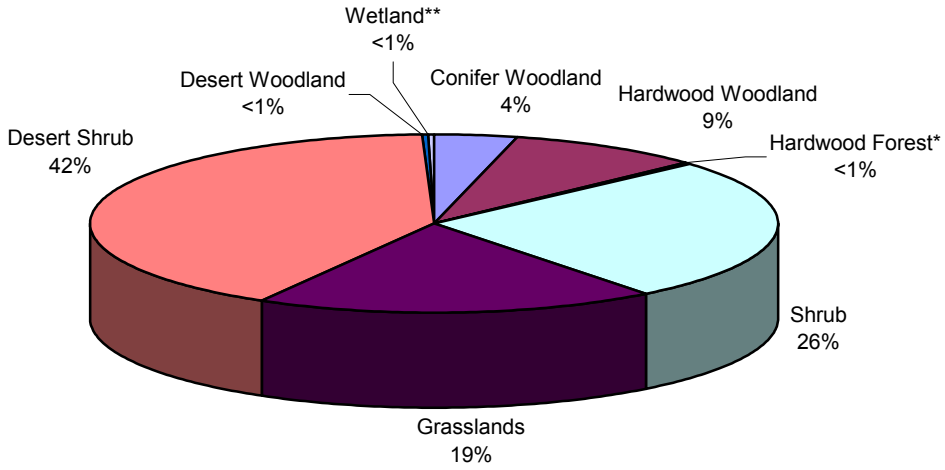
Source: FRAP, 1999; FRAP, 2002a

The area of primary rangelands is approximately 57 million acres, or nearly 57 percent of the State. This reflects the land base circa 1997. The area of secondary rangeland, the conifer and upland hardwood forestlands that provide limited forage, is shown in Table 1a Secondary Rangeland.

Desert Shrub (23.5 million acres) accounts for 41 percent of the rangelands in California, although it provides a small portion of the total forage for grazing.

The primary rangeland land covers include Desert Shrub accounting for 41 percent (23.5 million acres); Shrub accounting for 26 percent (14.6 million acres); Grassland accounting for 19 percent (10.9 million acres); and Hardwood Woodland accounting for 9 percent (5.2 million acres) (Figure 1).

Figure 1. Percentage of primary rangeland area by land cover type

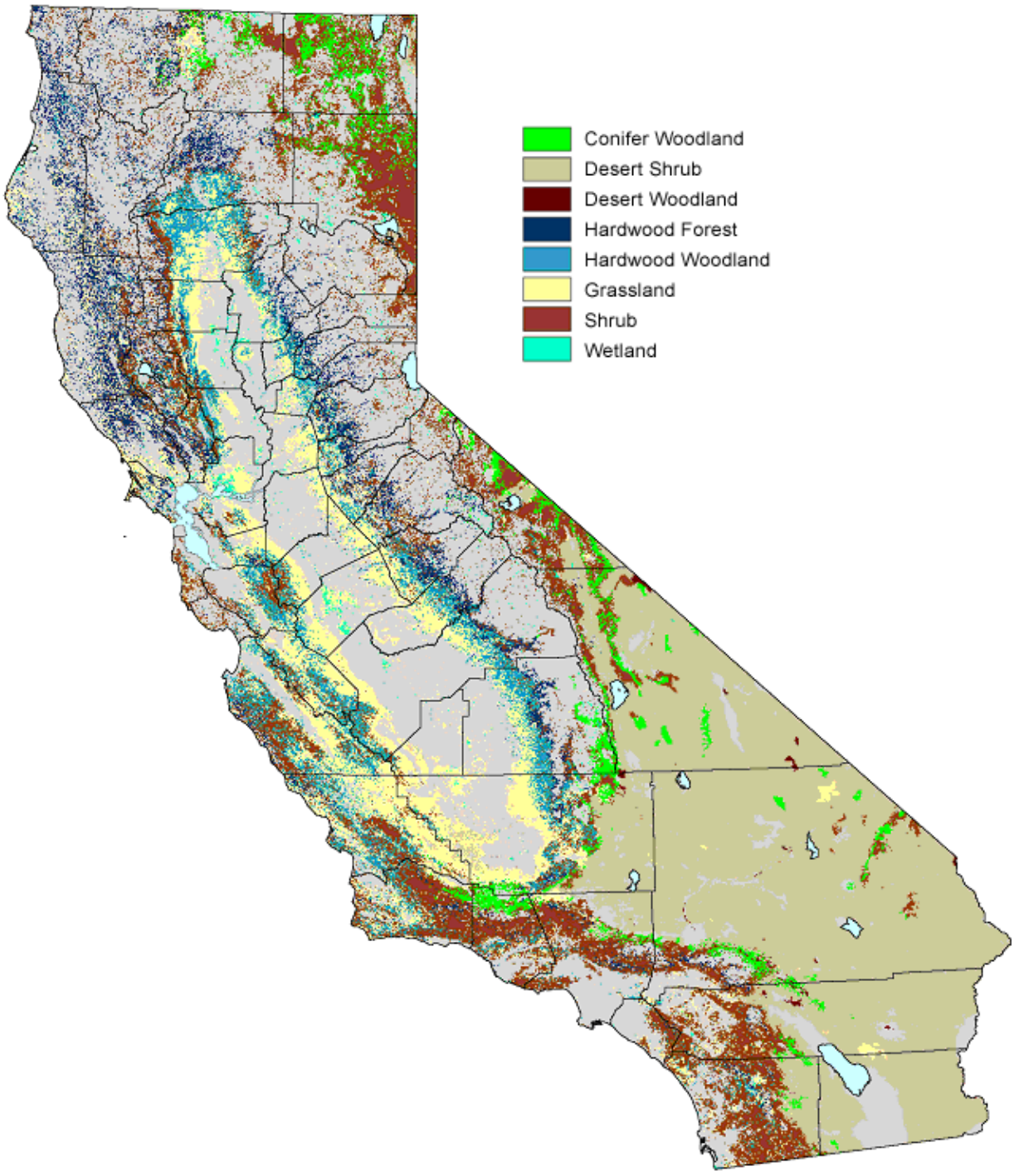


**Includes only Montane Riparian CWHR*
***Includes only Wet Meadow CWHR*

Source: FRAP, 2002a

Summaries of the rangeland area by county and bioregion can be found at Info and Data Center. Figure 2 shows the location of rangelands by land cover type.

Figure 2. Primary rangeland in California by land cover type



Source: FRAP, 2002a

Other estimates of rangeland area: In addition to the FRAP estimate of rangelands, there are other estimates that use different methods, definitions, and sources of information to summarize data. One source is the National Resource Inventory (NRI) of the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The NRI is a sample-based survey of the nation's non-federal rural lands. NRI monitors Statewide agricultural information as well as information relating to rangeland, forest land, and other habitats.

The 1997 NRI "Rangeland" area is estimated at 18.3 million acres, slightly less than the 19.4 million acre estimate made by FRAP for the comparable land base of privately owned shrub, grassland, desert and wetland rangeland cover types.

For completed information, see NRI Summary Report, 1997 (NRCS, 2000).

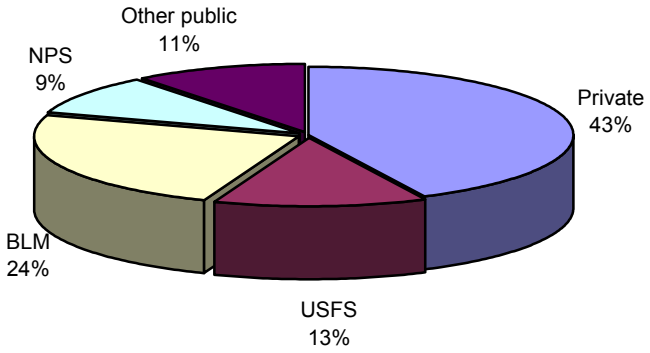
Findings on rangeland ownership, management patterns, available rangeland and lands actually grazed

Specific characteristics of the rangelands include regional ownership patterns, management or land use, the amount of rangeland area available for grazing (available rangeland*)*, and an estimate of the area actually grazed by livestock (grazing area). These metrics help define who owns rangelands, where rangelands are located, how they are managed and what portion of all rangelands are actually available and used for grazing livestock.

Rangeland ownership

A majority of the primary rangelands are in public ownership. Forty-three percent of rangeland habitats within California are privately owned while 57 percent are publicly owned (Figure 3). This ownership pattern varies among the bioregions of the State. As shown in Table 2, a majority of private ownership exists in four bioregions (Bay/Delta, Klamath/North Coast, Central Coast, and South Coast). The largest acreage of private rangeland is found in the Sierra and Central Coast bioregions.

Figure 3. Percentage area of primary rangeland by ownership, 1997



BLM – U.S. Bureau of Land Management; NPS – National Park Service; USFS – U.S. Forest Service

Source: FRAP, 1999; FRAP, 2002a

Table 2. Area of primary rangelands by major ownership and bioregion (thousands of acres)

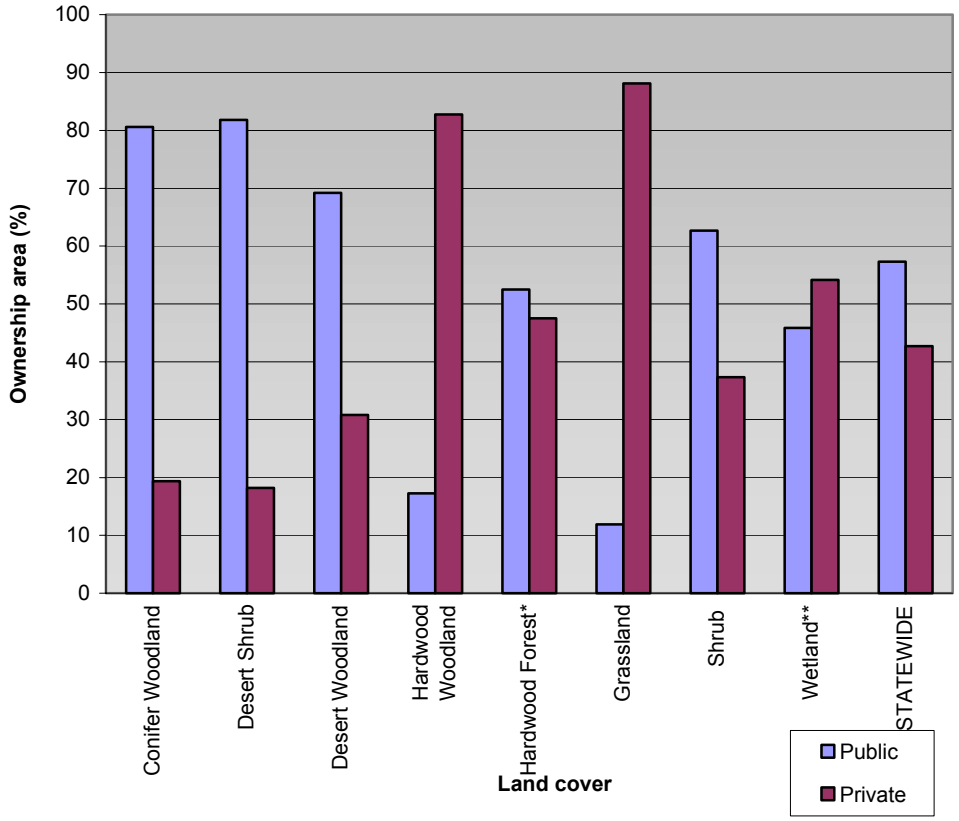
Owner	Bay/Delta	Modoc	Klamath/ North Coast	Sierra	Central Coast	South Coast	All others*	California
BLM	38	1,297	283	982	309	140	10,694	13,743
NPS	58	54	18	162	15	18	5,033	5,359
Other public	177	193	63	382	420	426	4,373	6,034
Private	2,031	1,549	2,457	3,396	4,598	1,992	8,328	24,350
USFS		1,325	829	2,512	1,474	1,305	132	7,577
Total	2,304	4,420	3,650	7,434	6,815	3,881	28,559	57,062

BLM – U.S. Bureau of Land Management; NPS – National Park Service; USFS – U.S. Forest Service
All others includes Mojave, Colorado Desert, Sacramento Valley, and San Joaquin Valley

Source: FRAP, 1999; FRAP, 2002a

Ownership of rangeland types is not evenly distributed. A majority of Hardwood Woodland, Grassland, and Wetland habitats are privately owned. In contrast, a majority of Conifer Woodland, Shrub, Desert Shrub, and Desert Woodland habitats are publicly owned (Figure 4). For acreage estimates by owner and habitat type see Table 3 Primary rangeland area by land cover type and ownership.

Figure 4. Percentage area of primary rangelands in public and private ownership by land cover class



Montane Hardwood Conifer CWHR type is not considered primary rangelands
****Only the Wet Meadow CWHR habitat type is considered primary rangelands***

Source: FRAP, 1999; FRAP, 2002a

Rangeland management patterns

Categories of management status are portrayed by the Management Landscape map which displays the geographic distribution of land use objectives, ownership, and population density (see FRAP Maps). This management landscape can be classified into eight broad categories, five of which are particularly relevant to rangelands as illustrated in Table 3. See Population and Land Use for definition of Management Landscape classes

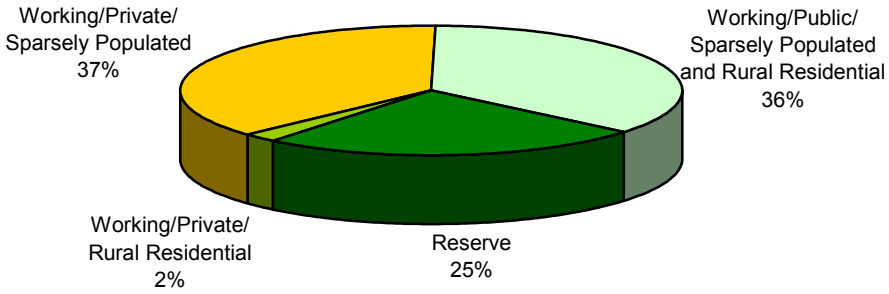
Table 3. Area and percentage of primary rangeland by management landscape class

Management landscape class	Area (million acres)	Percentage area of total rangeland	Management emphasis
Reserve	13.6	25	Consistent with these designations: wilderness, wild and scenic, national parks, national monuments. Commodity production prohibited or greatly restricted.
Working/Public/ Sparsely Populated and Rural Residential	19.8	36	(Sparsely Populated): lands under public administration with management consistent with agency mandate. Commodity production allowable. Housing density less than 1 unit per 20 acres. (Rural Residential): Lands under public administration with management consistent with agency mandate. Incurs complexities of surrounding people and structures. Housing density of one or more units per 20 acres and less than 1 unit per acre.
Working/Private/ Sparsely Populated	20.7	37	Lands under private ownership with management and commodity production consistent with governmental regulations. Housing density less than 1 unit per 20 acres.
Working/Private/ Rural Residential	1.4	2	Lands under private ownership with management and commodity production consistent with governmental regulations but more complex due to surrounding people and structures. Housing density of one or more units per 20 acres and less than 1 unit per acre. Often readily available for conversion to more intensive uses.

Source: FRAP 2002a; FRAP, 2002b

A majority of California's rangelands are in the Working/Sparsely Populated classification (73 percent). The balance is in the Reserve (25 percent) and Working/Private/Rural Residential (two percent) classifications (Figure 5). This suggests that rangelands predominantly fall in the category of working management landscape classes. In these classes, long-term use depends on management for commodity production (such as grazing) that ensures sustainable productivity.

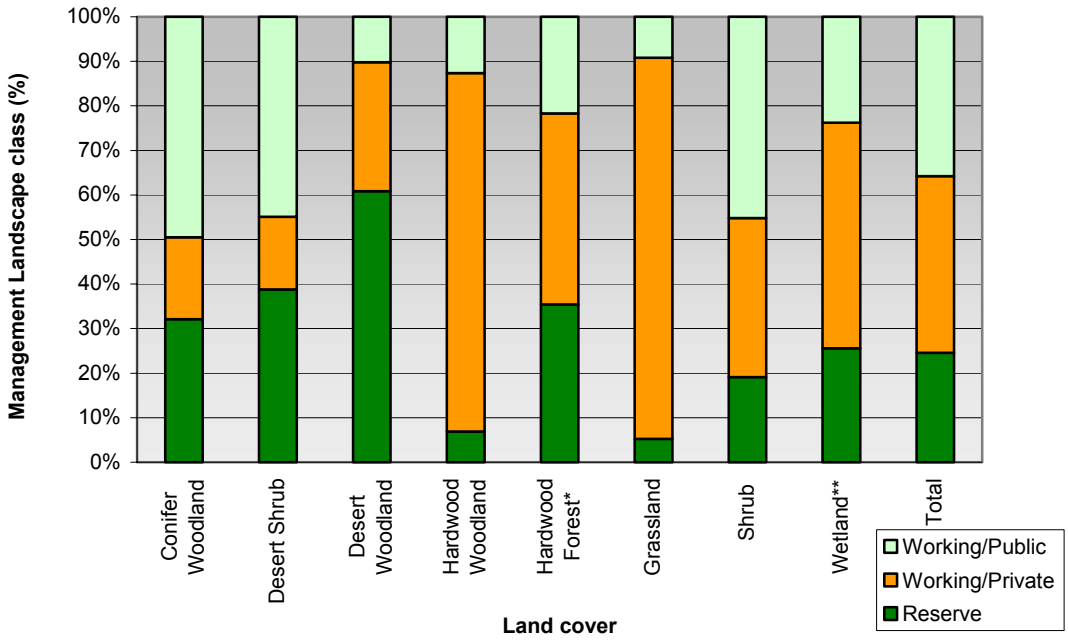
Figure 5. Percentage area of primary rangelands by management landscape class



Source: FRAP, 2002a; FRAP, 2002b

Rangeland land cover types are not evenly distributed among the different management classes. As shown in Figure 6, Grassland and Hardwood Woodland primarily occur in Working/Private classifications, which will be subject to increasing pressure from a growing population. However, Conifer Woodland and Desert land covers exist predominately in Reserve or Working/Public classes. These lands are considered to have a higher level of protection against threats to biodiversity than do land cover types predominately located in Working/Private classifications.

Figure 6. Percentage area of primary rangelands by land cover class and Management Landscape class



*Montane Hardwood Conifer CWHR type is not considered primary rangelands
**Only the Wet Meadow CWHR habitat type is considered primary rangelands

Source: FRAP, 2002a; FRAP, 2002b

Area of primary rangelands available for grazing

41 million of the 57 million acres of rangeland in the State are potentially available for grazing.

FRAP has estimated that there are potentially 57 million acres of primary rangeland are available for livestock grazing. However, a portion of this area is administratively excluded from grazing activities. To estimate the amount of primary rangeland available for grazing, termed available rangelands, FRAP uses the area of Working management classes (lands where resource use is typically allowed) and excludes land classified as Reserve management class (lands managed consistent with statutory designations such as wilderness, wild and scenic, national parks, and national monuments). The estimate of area of available rangelands is key to evaluation of rangeland sustainability, as it's used in a comparison of total annual rangeland forage production versus total annual use.

Table 4 and Figure 7 show the estimate of the available rangelands to be over 41 million acres. This means that about 72 percent of the total primary rangelands in the State are available for livestock

grazing. Public ownership of available rangelands totals 19.8 million acres and private ownership totals 21.9 million acres. While the portion of ownership between public and private available rangelands is similar, public lands contain large areas of Desert Shrub (53 percent of total public available rangeland). This desert type provides low levels of forage and offers limited grazing opportunities resulting in the increased potential for competition with other wildlife and concerns over sensitivity to environmental damage due to grazing. These concerns result in further dependence on the private rangelands to provide the majority of the forage needed for livestock grazing in California.

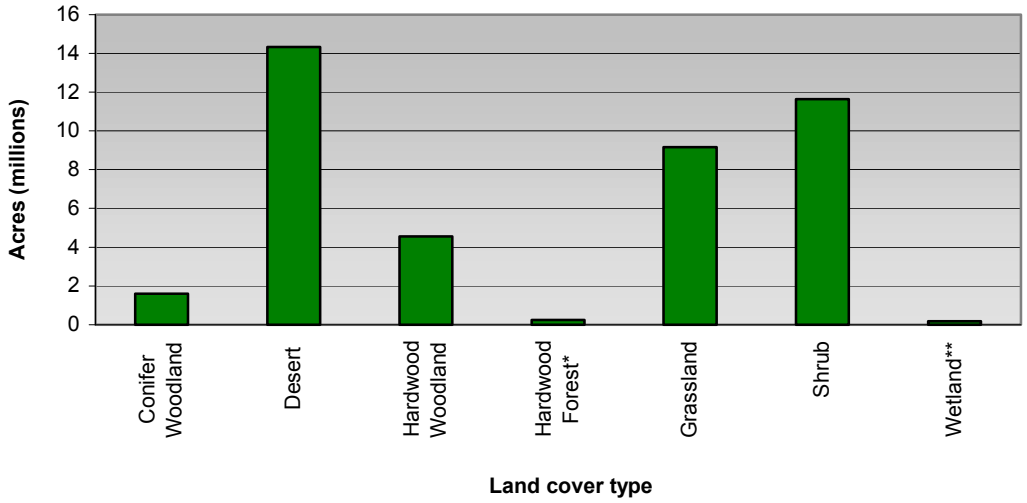
Table 4. Area of available rangelands by ownership and land cover class (thousands of acres)

Habitat Type	Private	Public	Total
Conifer Woodland	434	1,166	1,599
Desert Shrub	129	60	189
Desert Woodland	177	63	241
Hardwood Woodland	3,944	613	4,557
Hardwood Forest*	8,273	889	9,163
Grassland	5,135	6,504	11,638
Shrub	3,804	10,500	14,304
Wetland**	25	9	34
Grand total	21,920	19,805	41,725

Montane Hardwood Conifer CWHR type is not considered primary rangelands
****Only the Wet Meadow CWHR habitat type is considered primary rangelands***

Source: FRAP, 1999; FRAP, 2002a

Figure 7. Area of available rangelands by land cover type



Montane Hardwood Conifer CWHR type is not considered primary rangelands
****Only the Wet Meadow CWHR habitat type is considered primary rangelands***

Source: FRAP, 2002a

Estimating available rangeland area is problematic due to the following:

- Available rangelands estimate of 41 million acres includes areas that for various reasons (only steep canyons, areas distance from water sources) do not support grazing. Excluding these areas would decrease the total available rangelands.

- Secondary rangelands, such as Conifer Forest areas, that are known to support some grazing are not included in the 41 million acre estimate of total available rangelands. Some grazing is known to occur on forested lands, and if included would increase the area of available rangelands. See Table 5a for a complete list of types by management class.
- Some grazing occurs on Reserve lands, such as some federal, State and local park areas (e.g. East Bay Regional Parks District). However, the level of grazing and overall extent is minimal. If these reserved lands were included, they would increase the total area of available rangeland.

Grazing area

The area of land in California that actually has grazing of livestock is termed "grazing area." Field sampling conducted by the NRCS and allotment use records submitted by the USFS and U.S. Bureau of Land Management (BLM) determine the amount of grazing area.

The USDA Economic Research Service (ERS) is the only federal group that measures the total land grazed across all ownerships throughout the State. See the document Major Uses of Land in the United States, 1997 (ERS, 2001). This document represents the only consistent accounting of all major land uses in the United States. More detailed estimates of federal grazing land by ownership are derived from the document Rangeland Resource Trends in the United States (Mitchell, 2000) and are summarized in Federal Grazing Land. Table 5 shows the estimate of grazing area.

Table 5. Total grazing area in range and forest categories in all ownerships, 1997 (million acres)

Grassland and other pasture and range*	22.3
Forest land grazed**	11.8
Total grazing area	34.1

Grassland and other non-forested pasture and range in farms plus estimates of open or non-forested grazing land not in farms

****Woodland grazed in farms plus an approximation of forested grazing land not in farms***

Source: ERS, 2001

Summary and comparison of rangeland estimates

The many measures of rangelands in California include definitions offered by different monitoring agencies. The definitions used in this Assessment are shown below. Table 6 displays the integration of the many sources and definitions by ownership.

Rangelands or **primary rangelands:** the area of all rangelands, regardless of availability, with suitable vegetation for grazing livestock, excluding conifer forests and upland hardwood forests associated with conifer forests. Presents a broad estimate of rangeland area.

Available rangelands: primary rangelands excluding those lands (Reserve management class) that legally or administratively exclude livestock grazing.

Grazing area: an estimate of any forest and rangeland land cover type actually grazed by livestock.

Table 6. Various rangeland area estimates by ownership, 1997

	Private	Public	Total
Primary rangelands (FRAP)*	24.4	32.7	57.1
Rangeland (NRI)**	18.3	***	18.3
Available rangeland (FRAP)	21.9	19.8	41.7
Grazing area (ERS and RPA****)	17.4	16.7	34.1

ERS – Economic Research Service; FRAP – Fire and Resource Assessment Program; NRI – National Resource Inventory; RPA – The Forest and Rangeland Renewable Resources Planning Act of 1974

Excludes conifer forest types
****Excludes any hardwood or conifer forest types***
*****National Resources Inventory (NRI) measure some non-federal public lands but are included in private in this table***
******RPA (Mitchell, 2000) estimates used to derive area on public land***

Sources: Mitchell, 2000; FRAP, 1999; FRAP, 2002a; NRCS, 2000; ERS, 2001

This table suggests several findings:

34.1 million acres of the 57 million potential rangeland base is actually grazed.

- When comparing grazing area (34.1 million acres) with primary rangelands (approximately 57 million acres), it appears that primary rangeland area far exceeds the land base actually grazed. This means that there are a substantial area of rangelands were grazing in not permitted and land is managed primarily for ecological values.
- A large proportion of available rangelands (82 percent or 34.1 million of 41.7 million acres) are already being grazed. This results in limited opportunities for new grazing activities especially when considering the on-going decline in the available rangeland base in California.
- On public lands, large areas are not available or used at minimum levels for grazing due to exclusion by administrative designations and relatively poor forage production. Approximately 17 million acres of the nearly 33 million acres of public primary rangelands are grazed (52 percent). Over half of the 17 million acres is in desert land cover types that produce little forage and are very susceptible to environmental damage due to grazing.
- Private rangeland is used for grazing at a much higher level than public lands. Seventeen million of the 24 million acres of private primary rangeland is grazed (71 percent).
- The ecological implications of this use suggests that private rangeland are more widely used for grazing, raising the risk of environmental concerns. Other implications are that public lands are more likely used for wildlife habitats for species not dependant on grazing, benefits of fire reduction due to grazing are likely better realized on private lands, and successional changes are more likely on public lands.

Findings on forage production, grazing capacity and use

One method to assess the productive capacity of rangelands includes comparing the amount of vegetation available for grazing (forage production) and the extent to which this vegetation is used (use). However, direct estimates of rangeland forage are not comprehensively collected, unlike counterpart measurements for forests (standing board foot volume of forests and harvest levels). This deficiency limits a direct assessment of sustainable forage production and use.

California's primary rangelands available for grazing (largely comprised of Grassland) annually produce more than 30 million AUMs.

Proxy methods must be used to assess forage production and use. Forage production estimates are made by estimating grazing capacity, the maximum stocking rate possible without inducing damage to vegetation or related resources, measured in animal unit months (AUMs) per acre by vegetation, ownership, and region. To measure use, FRAP uses the number of livestock (specifically beef cattle grazed on rangelands) to evaluate use from a commodity point of view (Mitchell, 2000). Estimates of forage use are derived by approximating the inventory of animals in California. However, before proceeding with proxy estimates of forage production and use, forage types of California's rangelands are reviewed.

Forage types

Forest and rangelands provide forage (browse and non-woody plants) used for grazing by livestock and game. Forage varies in its quantity by species, time of year, and other factors such as climate, soils, and topography. Cattle consume a varied diet on rangeland that may include grasses, legumes, forbs, and brush (browse). Frequently, range forage does not provide a sufficient amount or quality of feed. This lack can lead to periods of malnutrition and slower growth especially in younger cattle. At such times, owners must supplement feed or move the cattle to locations where feed is available.

The major land cover types provide varying amounts of forage and include Grassland, Wetland, Hardwood Woodland and Forest, Desert Shrub, Desert Woodland, Shrub, and to a lesser extent Conifer Woodland and Forest.

Grassland: Grassland types are the most important source of forage for California livestock. Previous analysis by FRAP in 1985 suggests that grasslands supply many times the amount of AUMs of other vegetation types. The number of AUMs produced by grasslands varies by geographic region with averages ranging from .75 to 1.5 AUMs per acre (Conner, 2003).

Wetland: Wetland types generally include the upland riparian areas and wet meadows found within a variety of Grassland, Hardwood, and Conifer Forest types. This is a very small percentage of the rangeland area but particularly valuable from a forage production and an aquatic habitat perspective. The number of AUMs produced by wetlands varies greatly by geographic region with averages ranging from one to nine AUMs per acre.

Hardwood Woodland and Forest: Hardwood Woodland and upland Hardwood Forest types are the second largest source of forage used for grazing. These land cover types provide grasses for early season forage. Acorns and twigs provide important late season protein when annual grasses and forbs have dried. The amount of forage produced by Hardwood land covers varies not only by region but also by density of tree cover. Research conducted by the Integrated Hardwood Range Management Program (IHRMP) shows optimum forage level is achieved with moderate hardwood canopy coverage. These types typically yield about .75 AUMs per acre. See University of California Integrated Hardwood Range Management Program.

Desert Shrub and Woodland: While vast in area, Desert types provide very low amounts of forage. An average of 0.05 AUMs per acre are available on Desert types. For comparison, Desert land cover types can support 40 times less cattle than the Grassland type. This means that while 100 acres of Grassland could support 200 cattle for a month, 100 acres of Desert could support five cattle for a month. Typically, Desert land cover types are used only after rainfall in the winter months.

Shrub: Shrub land cover types are also vast in area and carry relatively low amounts of forage. Forage concentrations are as low as 0.1 AUM per acre in the dense chaparral lands of southern California and as high as one AUM per acre in the more open north coast Shrub types. Included in this group are sagebrush lands that are important sources of forage in the eastern and northeastern areas of the Sierra bioregion.

Conifer Woodland: Conifer Woodland land cover types generally consist of juniper and pinyon pine species on the east side of the Sierra bioregion. These habitats generally produce small amounts of AUMs, per acre usually less than .5 AUM per acre.

Conifer Forest: Although not considered a primary rangeland type, some Conifer Forest land cover types provide summer forage. Since forage production has an inverse relationship to canopy cover, conifer forests such as Redwood and White Fir produce little forage, while eastern Sierra bioregion pine forests provide only about .05 AUM per acre (Lindstrand, 2003). Conifer Forest is considered a secondary range type and is not used in the estimate of total forage production.

Grazing Capacity estimates

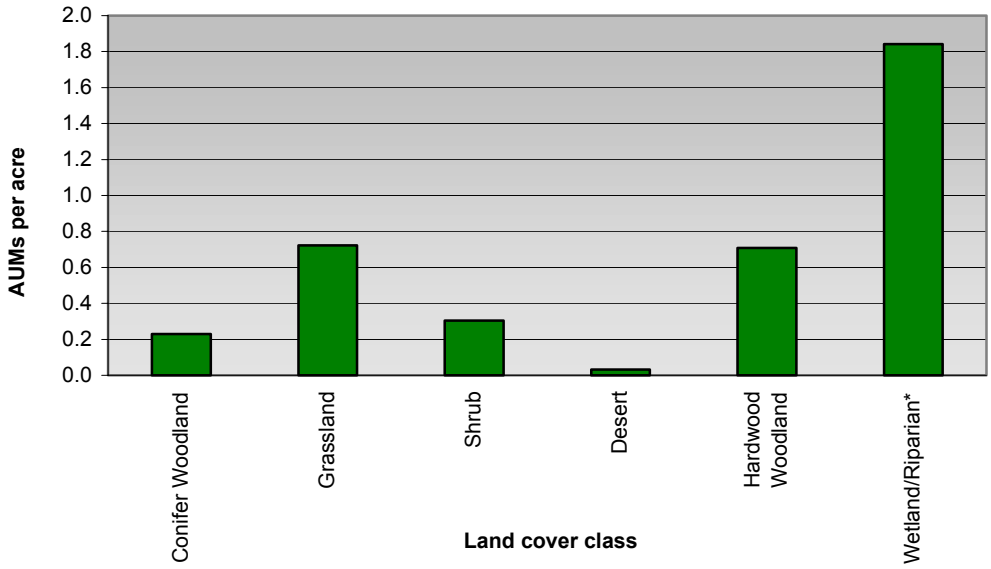
Landowners rely on forage that exists on both publicly and privately owned lands and in a variety of vegetation types. Forage is measured in the form of AUMs, the amount needed to sustain one mature cow and her calf, five sheep, or six deer for a month. An AUM is approximately 800 to 1,100 pounds of dry biomass, and represents the amount of forage that can be removed annually while still maintaining productivity.

FRAP has not updated or designed an information system that evaluates forage production or estimates AUM usage since the 1989 Assessment. Because forage production may not be the critical limiting factor affecting rangeland productive capacity, it is unlikely that models supporting this dynamic will be extensively developed. Many other trends, particularly the declining land base and the presence of

non-native, invasive species, are likely more important factors affecting long-term sustainability of rangeland productivity.

Previous assessments (CH2M HILL, 1989) have estimated the forage production for both primary rangelands and secondary lands (Conifer Forests) producing forage. In this assessment, grazing capacity is used to estimate the sustainable level of grazing which a vegetation type can support, not the actual annual growth of range biomass. Grazing capacity is defined as a stocking rate that is possible without inducing damage to vegetation or other resources. Figure 8 and Tables 7 and 8 show annual grazing capacity by land cover types in terms of AUMs per acre. Over 14 million AUMs are produced on California's available primary rangelands.

Figure 8. Average annual grazing capacity (AUM per acre) by primary rangeland cover class



*Includes montane riparian CWHR, valley foothill riparian CWHR, and wet meadow CWHR

Source: FRAP, 2002a; CH2M HILL, 1989

Table 7. Total annual forage production on available primary rangelands by land cover class

Land cover type	Grazing Capacity in AUMs per acre	Area (millions of acres)	Total AUMs (millions)
Conifer Woodland	0.2	1.6	0.4
Grassland	0.7	9.2	6.6
Shrub	0.3	11.6	3.4
Desert	<0.1	14.3	0.5
Hardwood Woodland	0.7	4.6	3.2
Wetland/Riparian*	1.8	0.4	0.8
Total	0.4	41.7	14.8

AUM – animal unit month

*Includes montane riparian CWHR, valley foothill riparian CWHR, and wet meadow CWHR

Source: FRAP, 2002a; CH2M HILL, 1989; Conner, 2003

Table 8. Total annual forage production on available secondary rangelands by land cover class

Land cover type	Grazing Capacity in AUMs per acre	Area (millions of acres)	Total AUMs (millions)
Conifer Forest and Montane Hardwood	0.04	19.1	.8

Source: FRAP,2002a; CH2M HILL, 1989, Lindstrand, 2003

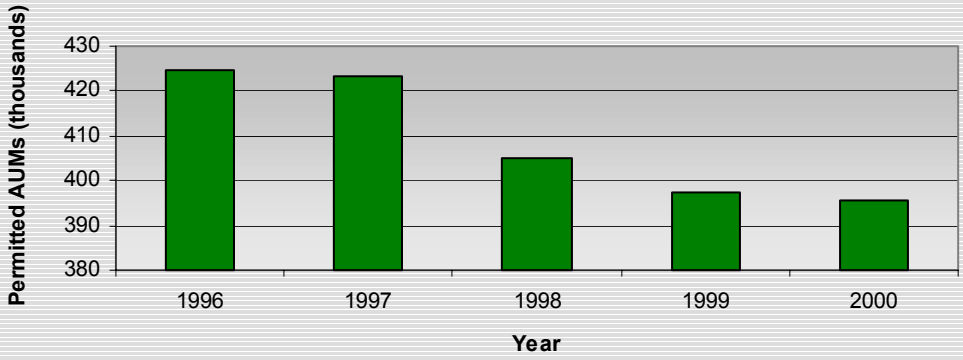
Forage use

Demand for forage on private lands may be increasing due to steady levels in statewide cattle inventories and a decline in grazing use on public lands.

Forage use is estimated indirectly by evaluating the inventory of beef cattle in a particular year and then calculating the AUMs needed to support that inventory. In 1997, nearly 1.9 million head of cattle were grazed annually for some period on primary and secondary rangelands (National Agriculture Statistics Service, 2001). To estimate the amount of forage used by these animals, the number of months used for range grazing must be estimated (see AUM Use Calculation). Using this methodology, it is estimated that over 11.8 million AUMs per year are consumed on California rangelands. For more information on the cattle inventory see the Assessment chapter Range Livestock Industry.

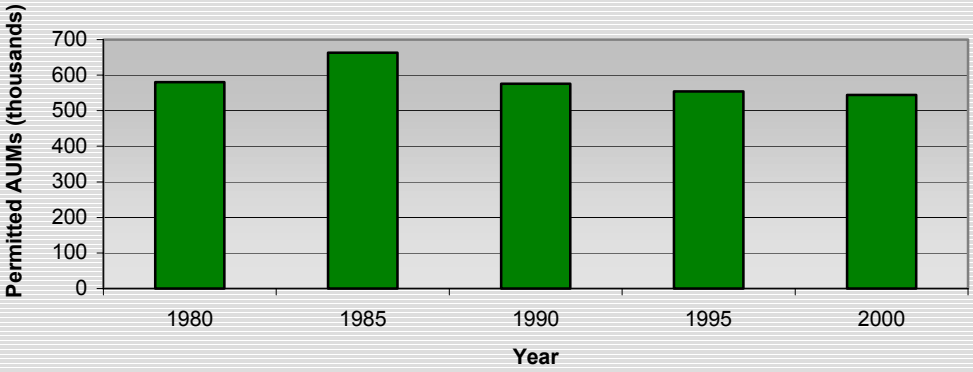
Forage use on public land. The use of forage on BLM and USFS lands is reported annually as the number of AUMs permitted in grazing districts or range allotments. As shown in Figures 9 and 10, permitted AUMs peaked in the 1980s and have steadily declined. This estimate suggests that less than one million AUMs come from use on federal lands. It also implies that the bulk of the estimated 11.8 AUMs used in California come from private lands even though the area grazed on public versus private land is nearly equal.

Figure 9. Number of AUMs on BLM lands with grazing permits and leases, 1996-2000



Source: Compiled by FRAP from USFS, 2002

Figure 10. Number of AUMs on USFS lands with grazing permits, 1980-2000



Source: Compiled by FRAP from USFS, 2002

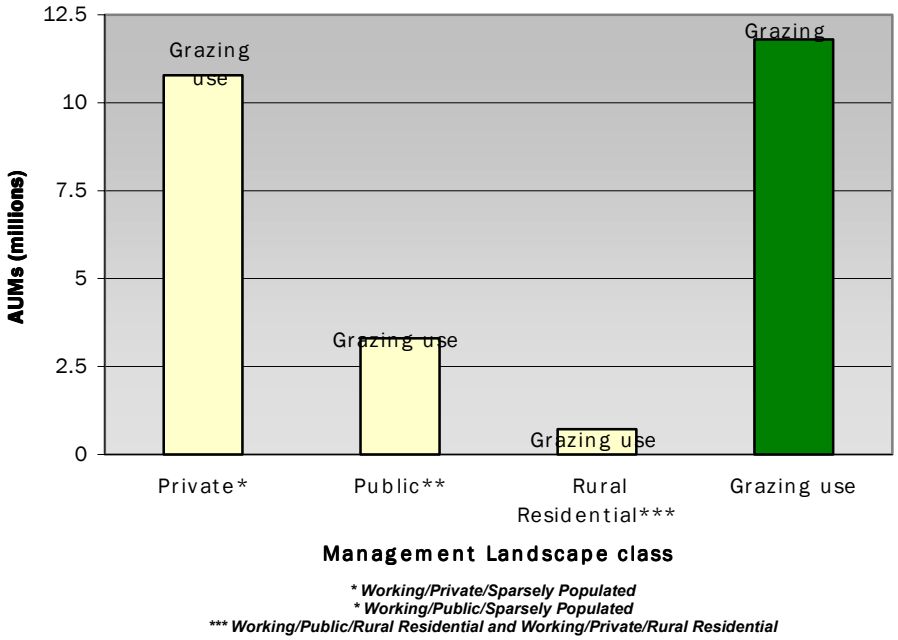
Comparisons of forage use and grazing capacity

Grazing capacity on available rangelands in places exceeds the amount used for grazing of domestic livestock (Figure 11). However, excess forage for grazing may not be available because of the seasonal nature of forage availability resulting in ranchers seeking additional feed sources.

The current estimate of grazing capacity on rangelands available for grazing is 14.8 million AUMs. The majority of forage available for grazing exists in the Management Landscape class Working/Private/Sparsely Populated (10.8 million AUMs). Domestic livestock grazing use in all classes is estimated at 11.8 million AUMs based on the approximately two million head of cattle that periodically graze on private rangelands.

This profile suggests that at a broad statewide level, rangeland productivity is being maintained and lands are currently being grazed at a sustainable level. However, specific factors raise questions on the capability of California's rangelands to sustain grazing activities at this level in the future. These concerns include a declining rangeland area, encroachment of invasive non-native species, and grazing use reductions on public lands resulting in potential increased demand for grazing on private lands.

Figure 11. Grazing capacity by Management Landscape class and total grazing use, available rangelands



Source: FRAP, 2002a; CH2M HILL, 1989; National Agriculture Statistics Service, 2001; Conner, 2003

Findings on change in rangeland area

Declining rangeland area is one of the more significant findings in this assessment. The decline in rangeland area reduces the role of private rangeland as cost effective provider of sustainable resource-based economic activity, certain wildlife habitats, and open space. The cost of acquisition and ongoing resource management is significant when the land is transferred to public ownership. The probability of conversion for residential or commercial use increases when ranching is no longer cost effective.

The rangeland base has been declining throughout the 1990s by tens of thousands of acres per year.

Several estimates are made regarding change in rangeland area. Each uses different analysis methods and different definitions of rangeland resulting in estimates that are not directly comparable. However, these estimates reflect the varying degrees of change in the rangeland base and all identify one clear trend: the rangeland base has been declining to some extent throughout the 1990s up to 90,000 acres per year.

Summarized below and displayed in Table 9 are three different estimates of change to the rangeland base. They are unrelated and are used to frame the possible extent of land change.

- FRAP, Census Housing Density Analysis, 1990 to 2000 (Pacific Forest Trust; FRAP, 2001; FRAP, 2003a);
- NRI, Change in Land Use, 1982 to 1997 (NRCS, 2000); and
- FRAP Land Cover Mapping and Monitoring Program (LCMMP), 1990 to 1998 (FRAP, 2002c)

Complete information on these land base monitoring programs can be found at Changes in Rangeland Area.

Table 9. Changes in rangeland area or vegetation reported by various monitoring methods (thousand acres)

	FRAP Census Housing Density Analysis	NRI	FRAP LCMMP
Period	1990 to 2000	1982 to 1997	Various 5 year periods during the 1990s
Total area change	-587	-624	-422
Annual average change	-58 per year	-42 per year	-84 per year
Area includes	Weislander Map vegetation types (1940s): eastside conifer; chaparral; coast sage; grass; sagebrush; hardwood lands; woodland grass.	All non-federal lands with natural vegetation available and suitable for grazing of domestic livestock. Excludes forested conifer and hardwood lands.	Hardwood and Shrub lands classified by FRAP.
Change reflects	Changes to high-density development (greater than one housing unit per acre) and low-density development (at least one housing unit per 20 acres). No other causes modeled.	Net transfer and land conversion to developed use, agricultural uses, forest land, and federal ownership.	Small to large changes in the vegetation canopy cover. Does not imply complete land conversion.

FRAP – Fire and Resource Assessment Program; LCMMP – Land Cover Mapping and Monitoring Program; NRI – National Resource Program

Source: FRAP, 2001; NRCS, 2000; FRAP, 2002c; FRAP, 2003a

Future changes in rangeland area

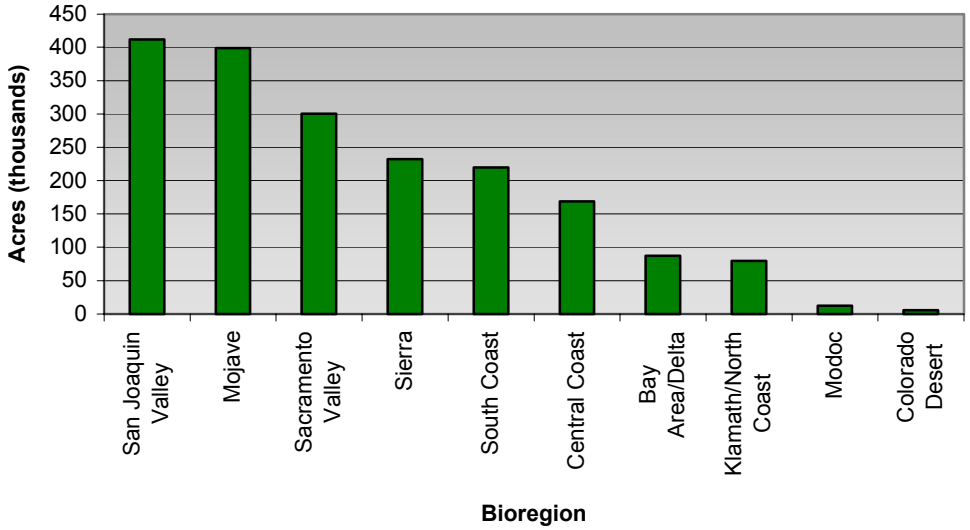
The rangeland available for grazing is likely to experience continued reductions in the future. More permanent land conversions to housing, commercial development and agricultural and other land transfers to public ownership are all likely to reduce the land available for grazing (see sidebar).

Administrative changes in BLM lands available for grazing: As noted in the 2000 Resources Planning Act Rangeland Resource Trends in the United States, over 5.4 million acres of California rangeland owned by BLM were re-classified as non-grazing between 1986 and 1996, the largest being the 1.6 million acre Mojave National Preserve created by the California Desert Protection Act. This represents an example of grazing land being administratively removed from the grazing land base.

To help identify the impact of housing development on California's rangelands, FRAP has modeled the projected change in rangeland area that may be attributed to housing and commercial development. This model projects the area of new "development" high-density urbanization (housing unit density greater than one unit per acre) and low-density development (housing densities between one unit per acre and 20 units per acre) by the year 2040.

As shown in Figure 12, substantial areas of rangeland are projected to have development impacts over the next 40 years, with the Sierra,, Mojave and South Coast bioregions expected to be most impacted. Table 10 shows that nearly 2.0 million acres of rangeland are projected to be developed between 2000 and 2040, with the bulk of the development likely to occur in the Grassland, Shrub, Hardwood Woodlands, and Desert Shrub land covers.

Figure 12. Projected rangeland development* by bioregion, 2000-2040



Densities of one housing unit per 20 acres or greater

Source: FRAP, 2002a; FRAP, 2003b

Table 10. Projected rangeland development* in California, 2000 to 2040 (thousands of acres)

Land Cover type	2000-2010	2010-2040	2000-2040
Conifer Woodland	6	11	17
Desert Shrub	49	216	265
Desert Woodland	2	2	3
Hardwood Forest**	3	3	6
Hardwood Woodland	147	316	463
Grassland	190	456	646
Shrub	165	348	514
Wetland***	1	2	3
Total Rangeland	563	1,354	1,917

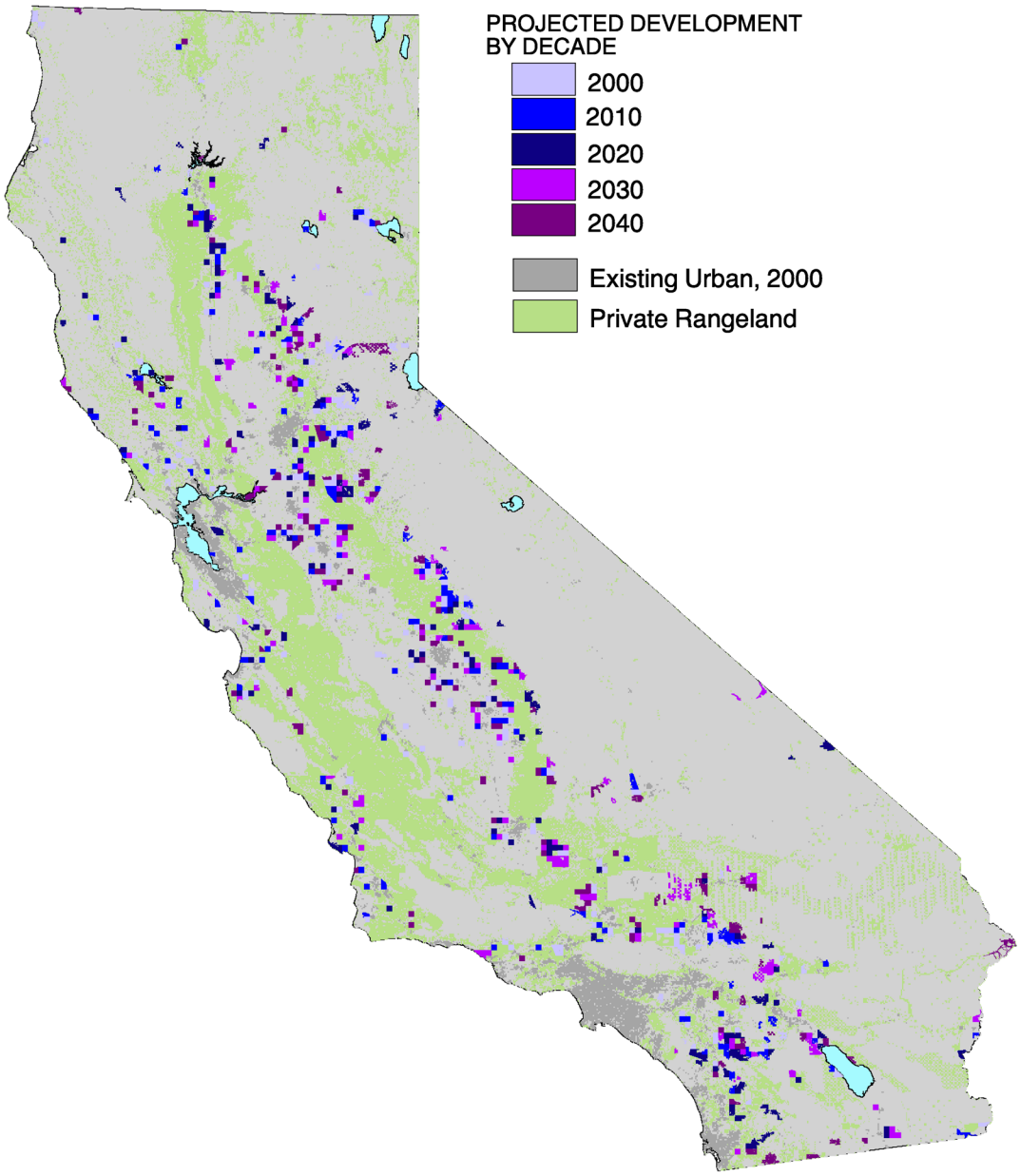
Densities of one housing unit per 20 acres or greater

**Montane Hardwood Conifer CWHR type is not considered primary rangelands
***Only the Wet Meadow CWHR habitat type is considered primary rangelands

Source: FRAP, 2003b

Projected development of rangelands will not be evenly distributed throughout California. As shown in Figure 12, the Sierra bioregion is expected to incur the highest level of development on rangelands for 1990 to 2040. Over 600,000 acres of rangeland will potentially be affected. Complete regional statistics on projected development by land cover and CWHR habitat type can be found at Information and Data Center.

Figure 13. Projected development of rangelands, 2000 to 2040



Source: FRAP, 2003b

Changes in Williamson Act enrollment

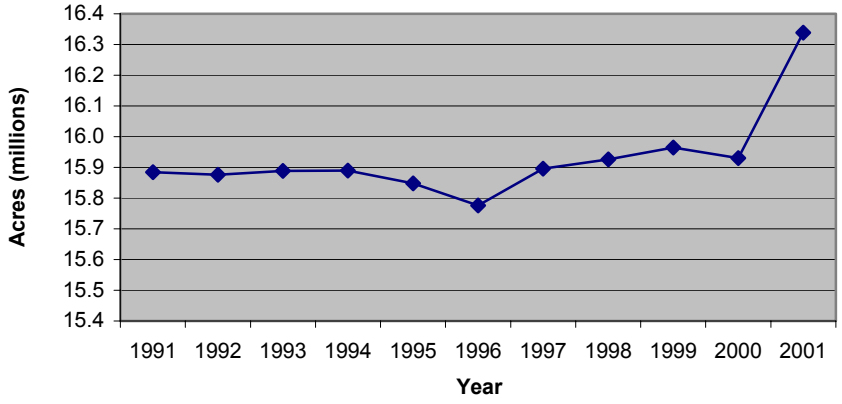
An indication of the future status of the rangeland base is the trend in Williamson Act enrollment.

Another indication of the future status of the rangeland base is the trend in Williamson Act enrollment. The Williamson Act is common terminology for the special zoning designations resulting from the California Land Conservation Act of 1965. Under this act, private landowners may enter into contracts with local government for restricting specific parcels of land to agricultural or related open space use. In exchange, landowners are taxed on values based upon farming and open space uses. These values usually are much less than full market value of the property for other uses so the resultant tax bill is lower. See California Department of Conservation Williamson Act Program.

The amount of farmland and rangeland enrolled in Williamson Act has been relatively stable during the 1990s, with increases beginning in 1998 with the passage of the Farmland Security Zone provisions (see Figure 14). However, these increases are mostly related to farmlands, not non-irrigated rangelands. The increased acreage enrollment suggest further protection of various farmlands and some rangelands from conversion to other urbanized uses in the near future.

At the end of 1998, about 15.9 million acres were enrolled under Williamson Act contracts, Statewide. This amount is nearly half of California's total farm and rangeland. Of this amount, 5.46 million acres is labeled as prime land. "Prime" covers several categories of higher production capacity under the Williamson Act (GC 51201(c)) including land with a livestock capacity of at least one animal unit per acre per year. The remaining 10.24 million acres are classified as "non-prime" and usually cover rangeland, open space, and low yielding crops (California Department of Conservation (DOC), 2002). Figure 14 shows the trend in Williamson enrollment for all classifications of land (DOC, 2002). See Williamson Act enrollment for classification and county specific information.

Figure 14. Statewide Williamson Act enrollment (all classifications), 1991-2001, (million acres)



Source: DOC, 2002

While the total enrollment of acres in Williamson Act has increased, the changes in enrollment have not been equally spread across bioregions and counties. When focusing on the changes in "non-prime"

acreage, the classification most reflective of rangelands, several bioregions show downward trends in enrollment (Table 11).

Table 11. Bioregion change in non-prime Williamson Act land enrollment, 1991-2001 (acres)

Bioregion	1991	2001	Acreage change	Percentage change
Decrease				
Mojave	19,712	11,504	-8,208	-42
South Coast	132,210	83,145	-49,065	-37
Bay Area/Delta	1,134,963	1,077,580	-57,383	-5
Sierra	722,685	710,517	-12,168	-2
Increase				
Central Coast	2,402,082	2,500,991	98,909	4
North Coast/Klamath	996,111	1,021,683	25,572	3
Modoc	261,347	264,794	3,447	1
San Joaquin Valley	2,776,098	2,794,443	18,345	1
Sacramento Valley	1,739,533	1,742,628	3,095	<1

Source: DOC, 2002

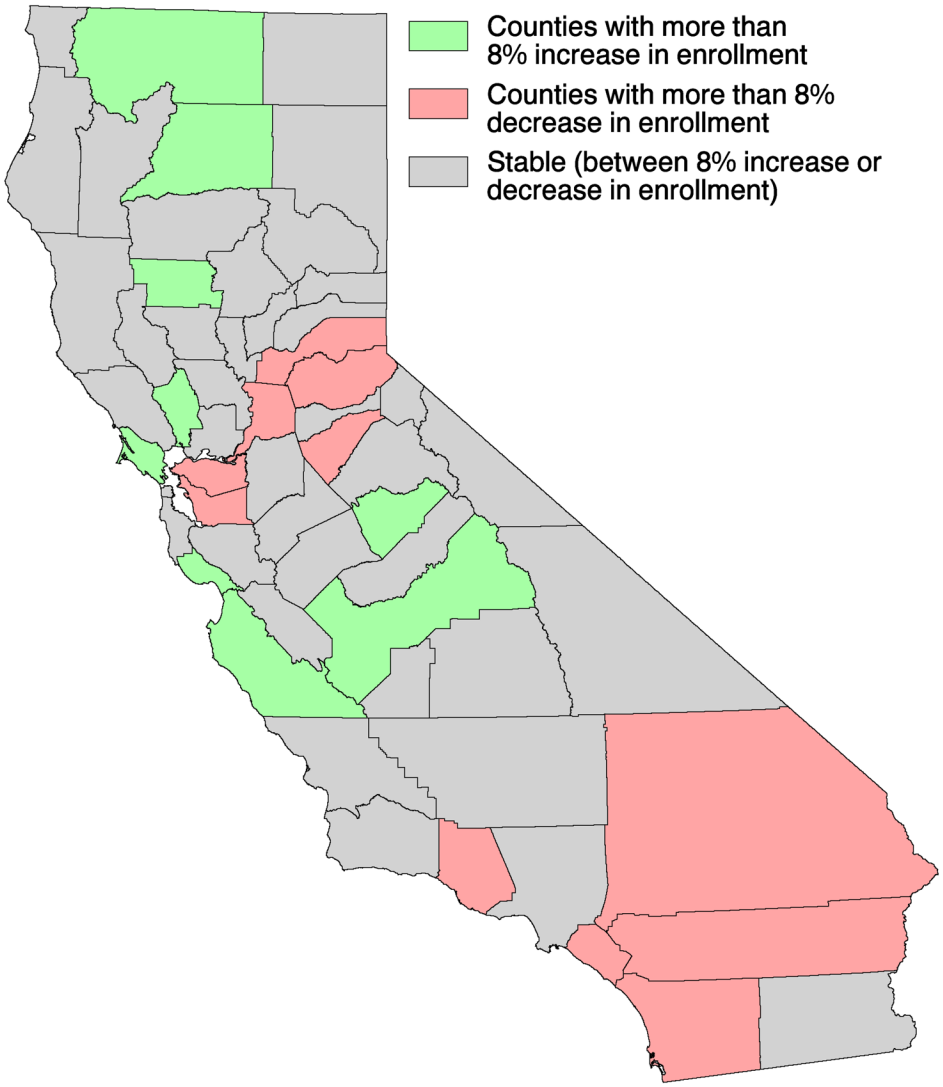
Similarly, trends in enrollment vary by county. Table 12 and Figure 15 show counties with changes between 1991 and 2001 in non-prime William Act enrollment of least eight percent. As shown, counties near rapidly growing population centers are showing substantial decreases in non-prime land enrollment. Conversely, Santa Cruz and Mariposa counties have shown substantial increases in non-prime enrollment.

Table 12. Counties with greater than eight percent change in non-prime Williamson Act land enrollment, 1991-2001 (acres)

County	1991	2001	Acreage change	Percentage change
Decrease				
Orange	41,230	11,912	-29,318	-71
San Bernardino	9,132	4,790	-4,342	-48
Placer	49,256	28,395	-20,861	-42
Riverside	10,580	6,714	-3,866	-37
Contra Costa	60,748	39,965	-20,783	-34
Sacramento	124,220	89,659	-34,561	-28
Ventura	101,824	78,536	-23,288	-23
San Diego	90,980	71,233	-19,747	-22
El Dorado	48,434	38,792	-9,642	-20
Alameda	143,388	126,806	-16,582	-12
Calaveras	133,007	121,005	-12,002	-9
Increase				
Santa Cruz	8,553	16,511	7,958	93
Mariposa	165,751	198,554	32,803	20
Shasta	136,767	150,793	14,026	10
Monterey	623,095	675,086	51,991	8
Napa	46,806	50,532	3,726	8
Marin	83,089	89,602	6,513	8
Siskiyou	294,083	317,017	22,934	8
Glenn	250,041	269,214	19,173	8
Fresno	452,904	487,075	34,171	8

Source: DOC, 2002b

Figure 15. County trends in non-prime Williamson Act land enrollment, 1991 to 2001 (percentage change from 1991 base year acres)



Source: Compiled by FRAP from DOC, 2002

Summary of changes in rangeland area and use

In summary, many factors are likely to affect rangeland area available for grazing such as conversion of lands to other uses and administrative withdrawals. Other factors, as discussed in the next pages, including general ecological conditions and habitat degradation due to exotic species invasion will also play a role in the forage productivity of rangeland. As a result of these factors, there eventually may be grazing use limitations. However, as discussed in Range Livestock Industry, market factors (e.g., reduced demand for red meat, price competition from foreign sources, etc.) may have a greater impact on grazing requirements than land base reductions.

Findings on rangeland condition

When livestock graze rangelands, physical changes and interruption of ecological processes can occur such as soil compaction, redistribution of nutrients and seed, and shift in plant composition (Menke et al., 1996). When these physical changes are within a normal range of variation, plant and animal communities and ecological processes can be maintained and grazing is likely being supported at sustainable levels. The monitoring and evaluation of these conditions and processes are fundamental to assessing rangeland "condition."

Cattle grazing on Grassland land cover.

To assess rangeland condition, estimations are made of the integrity of soil (soil loss and stability), water quality (hydrological function) and plant community composition (integrity of biotic community) (Pellant, 2000). These are recognized as the most important factors because they are indicative of the status of the ecological function needed for long term sustainable forage production.

To present information on the status of rangeland condition, several topics and issues related to soil, water, and plant composition are reviewed as summarized below:

- status and trends in rangeland soil and water quality including soil erosion, water quality management plans, and identification of rangeland waterbody impairments as defined by the California State Water Resources Control Board (SWRCB);
- status and changes in plant compositions towards altered ecological states including:
  - hardwood woodland and grassland condition evaluations;
  - spread of exotic plants in California rangelands and its affect on the plant composition;
  - encroachment of juniper woodlands onto grasslands in the eastern Sierra Nevada and northeastern California; and
  - decline of quaking aspen (*Populus tremuloides*) in the Sierra Nevada as it relates to diversity in the local plant community.
- technologies and range improvement methods;
- institutional protocols for monitoring rangelands including discussion of current trends in state and transition models; and
- existing agency-specific rangeland condition assessments including those reported for California by the USDA NRCS for non-federal rangelands and by the USFS and BLM for federal lands.

Findings on soil and water conservation

While only a portion of total precipitation falls on California rangelands almost all surface water in California passes through rangeland. In addition, two-thirds of the major reservoirs are located on rangeland. Therefore, rangeland hydrology greatly influences the quality of California's surface waters (Harper et al., 1998a).

Only about 15 percent of the total precipitation falls on rangeland but almost all surface water in California passes through rangeland.

The grazing activities conducted on rangelands and their effects on soil and water quality are of particular concern for maintaining hydrological function. The impacts grazing has on hydrologic conditions depends primarily on the behavior of the animal including feeding, drinking and waste production, and traveling. Timing and the intensity of grazing also have an impact. The resultant effects of these behaviors can lead to excessive vegetation removal (over-grazing), potential erosion due to soil baring, accelerated channel bank erosion due to trampling, stream temperature increase due to removal of riparian vegetation, water pollution from direct nutrient and pathogen deposits, and habitat degradation in wet meadow areas (Harper et al., 1998b). Key issues related to water quality are cost effective management of riparian zone grazing practices.

Rangeland erosion

Much of California's rangeland is composed of annual grassland for which evaluation guidelines and procedures do not exist in USDA (NRCS) or BLM assessments. California's annual grassland sites present a unique erosion hazard since soils are frequently thin, topography steep, and precipitation often received in the form of rain rather than snow. As a result, there is the potential for certain sites to lose much of their soil's productive potential (George et al., 1990). California erosion assessments estimate that an average yearly loss of 3l3 tons per acre occurs on one-third of the private rangelands from sheet and rill erosion. Furthermore, streambank erosion is another potential source of sediment loss on more than 9,000 miles of streambanks (Harper et al., 1998a). See the document Rangeland Watershed Program - Fact Sheet No. 1 (Harper et al., 1998a).

Annual Grassland sites present a unique erosion hazard since soils are frequently thin, topography steep, and precipitation often received in the form of rain rather than snow.

Rangeland Water Quality Management Plan

The SWRCB has developed a California Rangeland Water Quality Management Plan (RWQMP). This plan is in response to the increasing recognition that non-point source pollution is an impediment to the maintenance of clean water as well as to the Coastal Zone Act Reauthorization Amendments adopted in 1990. The reauthorization places additional requirements on the State to address non-point source pollution in several categories including rangeland. The RWQMP limits its scope to water quality impacts on all non-federal rangelands, pasture, and other grazed lands. Irrigated pastures, hay, other croplands, confined animal feeding operations, and nutrient management are addressed by other technical reports to the SWRCB and as part of the integrated agriculture and agriculture processing industrial sectors. See the

document California Rangeland Water Quality Management Plan (California Cattlemen's Association, 1995).

The primary goal of the RWQMP is to maintain and improve the quality and associated benefits of surface water as it passes through and out of rangelands in California. The plan employs a voluntary, cooperative approach to water quality management using economically and technically feasible means, and will be adopted within the SWRCB Non-point Source Management Plan. The objective of the RWQMP is to conduct management activities in a manner that will prevent sedimentation, nutrients, pathogens, and thermal pollution from exceeding prescribed standards established by the Regional Water Quality Control Boards. Approximately, 1 million acres of private rangeland currently are enrolled in these plans (Conner, 2003)

Assessment and monitoring is a prominent component of the plan and takes place at the scale of the site and/or watershed. The primary components of this aspect of the plan include the following: 1) documentation of off-site uses and unplanned disturbances (fire, floods, drought, insects, freezes, etc.) that influence water quality; 2) documentation of implementation procedures, management strategies, or management practices; and 3) measurement of management practice effectiveness over time. This third component is an adaptive process that monitors management activity and recommends changes to meet desired objectives.

Total Maximum Daily Load program and water bodies with potential impairment sources related to rangeland activities

Under Section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop a list of sub-standard waters. The waters on this list do not meet water quality standards; even after the minimum pollution control technology required by law has been installed at the point sources of pollution. The law requires that these jurisdictions establish priority rankings for water resources on the lists and develop action plans, called Total Maximum Daily Loads (TMDLs), to improve water quality (SWRCB, 2000). See the document Section 303(d) List of Water Quality Limited Segments.

A TMDL is a written, quantitative assessment of water quality problems and contributing pollutant sources. It specifies the amount of a pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollution control responsibilities among pollution sources in a watershed, and provides a basis for taking actions needed to restore a waterbody. More information on forest and rangeland water quality concerns and the TMDL program can be found in the following Assessment sections: Watershed Quality and Assessment, and Legal Frameworks for California's Forest and Rangelands.

As part of the TMDL program, California submits a list of waterbodies experiencing impairments to their designated beneficial use to the U.S. Environmental Protection Agency. Identification of those water bodies in which rangeland use is a partial or contributing factor to impairment is a preliminary metric relating to the relative impact that grazing activities have on water quality. Potential sources of non-point source pollution caused by grazing include sediments (physical), nutrients (chemical), and pathogens

(biological), as well as thermal impacts attributable to changes in riparian conditions. Table 14, a review of the 1998 303d list of impaired waterbodies, indicates waterbodies by bioregion with some portion partially impaired by rangeland or grazing sources. For the types of pollution caused by rangeland activity, the majority are related to temperature and sediment stressors (SWRCB, 1999). See the document 1998 California 303(d) List and TMDL Priority.

Table 13. Impaired waterbodies* by bioregion related to rangeland and grazing pollution sources (1998)

Bay/Delta	Klamath/North Coast	Sierra
Estero De San Antonio	Garcia River	Eagle Lake
Llagas Creek	Navarro River	Aurora Canyon Creek
Americano Creek	Mattole River	Carson River, East Fork
Estero American	Eel River, South Fork	Clark Canyon Creek
Stemple Creek	Eel River Delta	Clearwater Creek
Russian River	Van Duzen River	East Walker River
Modoc	Eel River, Middle Main Fork	Goodale Creek
Fall River	Eel River, Upper Main Fork	Green Creek
Pit River	Tomki Creek	Hot Springs Canyon
Panoche Creek	Redwood Creek	Indian Creek
Central Coast	Trinity River	Mill Creek
Los Osos Creek	Trinity River, South Fork	Pine Creek
Salinas River	Scott River	Rough Creek
Morro Bay	Shasta	Scedaddle Creek
Chorro Creek		Tuttle Creek
Pajaro River		Wolf Creek

Impaired waterbodies in the South Coast bioregion (Santa Ana and San Diego Water Quality Control Board Regions) do not show specific source information.

Source: SWRCB, 2000

Findings on plant community composition

Plant community composition is the species type, structure (size and density), and diversity of vegetation on rangeland. The ability of the rangeland site to support these characteristics, resist loss of function and structure, and recover help define rangeland condition from a vegetative perspective.

Great changes have occurred to rangeland plant composition since the late 1800s and man's use of resources (Menke et al., 1996). Historic changes in rangeland vegetation, primarily for the Sierra bioregion, were marked by substantial over-grazing, introduction of large fires for forage improvement and unmitigated use of livestock forage in riparian areas. Substantial changes have taken place to recover the Sierra rangelands during the last two decades, including a slow recovery of upland wet meadows and re-vegetation of riparian areas following improvements in grazing practices.

Hardwood rangeland condition monitoring

California's hardwood rangelands are the nearly 10 million acres of hardwood forests and woodlands that are composed primarily of oak tree species but may also contain other hardwood tree species. The annual and perennial grasses found within California's hardwood rangelands are an important source of rangeland forage for the State's livestock industry (IHRMP, 2000a). See Values for Hardwood Rangeland Stands.

California's hardwood rangelands have historically been the one of the most important rangeland areas in the State and represent a large part of California's rangeland grazing capacity. These lands are generally located adjacent to the Sacramento Valley, San Joaquin Valley, and smaller coastal valleys within the Coast Range.

Soil and water quality conditions and trends are poorly quantified across hardwood rangelands.

While mapping efforts directed at California's hardwood rangelands are useful for translating vegetation condition into wildlife habitat values, they are less useful as assessment tools when measuring condition variables such as rangeland forage, soil, and water quality. As such, soil and water quality conditions and trends are poorly quantified across hardwood rangelands. Although these variables are generally assumed to be of great importance, there is neither the foundation to analyze current conditions nor the means to model future ones beyond site-specific analysis.

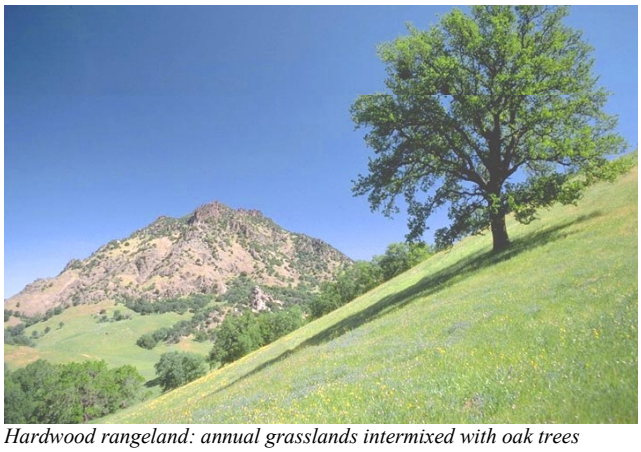
Livestock grazing has both positive and negative influences on hardwood rangeland condition. Positive influences include reduction in moisture competition between oak seedlings and annual grass species as well as reduction in fine fuels that influence fire spread rates. Negative influences on hardwood rangelands include potential for increased soil compaction, alteration of stream hydrologic function, and direct impact on oak seedling regeneration.

The Integrated Hardwood Range Management Program has made significant contributions toward the identification of sustainable management practices and ecological processes.

The University of California Integrated Hardwood Range Management Program (IHRMP) has made significant contributions toward the identification of sustainable management practices and ecological processes, specifically those affecting conditions and trends in the State's hardwood rangelands dominated by annual grass. This research on the grassland component of the hardwood rangeland ecosystem centers principally on rangeland condition monitoring methodologies as well as the removal or retention of oak tree canopy and the resulting effect on forage production. This emphasis arose in response to widespread clearing or reduction of oak woodland canopy from the mid-1940s to the early 1970s as a means to enhance forage production. More recently, permanent conversion to residential development or conversion to more intensive agricultural practices has reduced rangeland extent or otherwise impacted ranch management practices. See the web site University of California Integrated Hardwood Range Management Program (2000b). Some recent findings by IHRMP on sustainable practice research include canopy management of oak for improved forage yields and appropriate methods measuring the utilization of rangelands.

Canopy management of oak for improved forage yields: Oak removal has been recommended as a means to increase forage production by reducing competition for limited amounts of moisture and sunlight. Most studies on this topic have demonstrated that increased forage production is possible in rangelands dominated by blue oak (*Quercus douglasii*) if precipitation exceeded 20 inches per year and tree canopy densities exceeded 25 percent. In areas with less than 20 inches of rainfall and less than 25 percent canopy density, forage yields were greater than adjacent open grassland areas. Moderate blue oak canopy cover (25 to 60 percent) had a variable effect on forage production.

Current research on this topic concludes that the benefits of oak removal generally decline within 15 years due to the loss of an organic matter source sustaining soil quality and the disruption of the nutrient cycling processes. Conversely, there has been little impact on soil quality under light to moderate grazing pressures given organic matter inputs from grazing livestock. In addition, during periods of drought, the shading provided by an oak canopy results in longer retention of soil moisture, thus maintaining green forage for a longer period into the dry season.



Hardwood rangeland: annual grasslands intermixed with oak trees

Appropriate methods for measuring the utilization of rangelands: The scientific debate continues regarding appropriate methods for measuring the utilization of rangelands. However, there is a consensus that the basis of sustainable grazing management is one that balances forage demand with supply. Therefore, long-term maintenance and improvement of range condition requires forage rationing because all elements of vegetation management (rest-rotation grazing, prescribed burning, and prescribed grazing) operate using schedules of forage use based on a measure of supply and demand (Pittroff et al., 2000).

One measure of vegetation utilization examines residual dry matter (RDM) estimates. RDM is the dead plant material remaining from the previous growing season. Grass productivity (measured by quality and quantity) is influenced by the amount of RDM remaining on site in the autumn months and is used as a guideline to determine grazing intensity levels in annual grass dominated systems (Bartolome et al., 2002).

Monitoring the amount of RDM present on a site is useful when determining sustainable forage production on hardwood (annual) rangeland. The concept underlying RDM recommendations is that if an "adequate" amount of RDM is present during the first fall rains, the soil will be protected from erosion. This scenario establishes a microenvironment supporting optimum seedling establishment and growth, and incorporating sufficient organic matter into the soil to maintain soil fertility and water holding capacity. Experience demonstrates that moderate amounts of RDM result in higher forage production the following growing season. In contrast, heavy and light amounts of RDM do not result in such positive numbers. RDM recommendations will therefore naturally vary according to geographical, precipitation, and soil considerations (Frost, 1999).

Guidelines for utilizing RMD for managing annual rangelands have recently been revised, reflecting scientific data on RMD impacts (Bartolome et al., 2002). These guidelines and recent studies regarding mapping of RDM concluded that managers were better able to identify areas of heavy use and erosion potential when utilizing RDM maps. The studies also concluded that mapping RDM over the long term had additional benefits. These included both identification of grazing patterns and location of water and forage supplements, thereby expanding livestock use of the forage base. In addition, the studies provided

another means of evaluating grazing system effectiveness as well as justification for adjustment of stocking rates (Harris et al., 2001).

Condition of non-federal annual grasslands

Annual grasslands provide approximately 84 percent of the forage used for domestic livestock grazing on California's forests and rangelands. This percentage includes annual grassland as well as the annual grass understory component of valley and foothill woodland, coastal scrub, and chaparral land cover types. Early assessments mandated by Congress (e.g., Renewable Resources Planning Act, and Soil and Water Resource Conservation Act) reported California's annual rangelands to be in "poor" condition. This conclusion was based on an evaluation of California's grasslands according to perennial grassland standards. In these standards, assessment criteria and methods place annual-dominated plant communities into lower condition classes. The plant succession concepts and application methods developed for perennial grassland (such as Midwestern prairies) are not sufficiently similar to the annual grassland ecosystem function to allow comparison (George et al., 1990).

Identifying metrics and methodologies for assessing the health of annual grasslands is problematic because comparative data for undisturbed areas is largely absent. Furthermore, the absence of historical data along with the necessary research database needed to arrive at an accurate assessment of pre-disturbance annual grassland conditions compounds the problem. Annual grass species and invasive exotics so dominate the sites they occupy that conversion back to earlier conditions is unlikely, even in the absence of disturbance (George et al., 1990).

Invasive exotic plants in California rangelands

The spread or colonization of plant species outside their historic distribution is an important indicator of rangeland health and trends in productivity. Successfully established invasive exotic or non-indigenous species (species introduced into ecosystems in which they did not evolve) often expand in distribution because natural controls to the population (e.g., competition with other species or herbivory) do not exist or only occur at low levels in their new environment. Exotic species are generally associated with some form of disturbance facilitating their establishment and spread. Because they displace native species and alter ecosystem function, the occurrence of exotics in California rangelands can have significant ecological and economic consequences affecting productive rangeland management. Information on location and spread over time of specific exotic plant spread in rangelands can be found in the Assessment section Non-Native Invasive Species.

The influx of weed species is one of the single most significant indicators of overall annual grassland condition.

The influx of weed species is arguably one of the single most significant indicators of overall condition. Such weed species include yellow starthistle and medusahead (*Taeniatherum caput-medusae*), and their effect on the productive capacity of the land base to support livestock (N. McDougald pers. comm.). However, data is not readily available documenting effects and trends on productive capacity at a regional scale. This is mainly due to the highly variable influence of rainfall on annual plant productivity and the grazing schedule of individual ranch operations. Starthistle, for example, has significant and

widespread negative effects on both the water availability in the soil profile and the biological diversity of rangeland ecosystems. However, depending on the time of year, starthistle can provide suitable forage for cattle, sheep, and goats. Protein levels at the rosette and bolting stages of the plant's life history can be 8 percent and 17 percent, respectively, comparing favorably with alfalfa (Thomsen, 2001).

Exotic plants of concern on California's rangeland

The introduction of cheatgrass (*Bromus tectorum*) in the 1800s and subsequent expansion as a dominant understory plant in much of the sagebrush steppe within California and the Great Basin, has reduced the perennial grass component of that plant community and markedly altered the influence of fire on shrub species. This introduced annual out-competes native perennial grasses and provides the fine fuel necessary to carry fire during dry summer months to the detriment of fire intolerant shrub species such as sagebrush (*Artemisia sp.*) and bitterbrush (*Purshia tridentata*). Annual grasses are also less effective at soil protection than perennials, which contribute to increased levels of soil erosion during summer storms (BLM, 1998).

Several species of knapweeds and starthistles dominate (or have the potential to dominate) many of the land covers within California's rangelands.

Several species of knapweeds and starthistles dominate (or have the potential to dominate) many of the land covers within California's rangelands. Species within this genus are considered harmful to rangelands because they occupy sites in relatively good condition, increase soil erodibility, and negatively affect forage and wildlife habitat value (Mitchell, 2000). Yellow starthistle (*Centaurea solstitialis*) is perhaps the best-known example of the genus in California. This species has increased its range in California from one million acres in 1978 to over ten million acres currently (BLM, 1998) and has had a marked effect on local economies (DiTomaso, 2000). See the document Yellow Starthistle Information for more information. Although the species provides some forage value at certain times of the year, it is an effective competitor for available soil moisture, a situation that negatively affects native rangeland plant species and biological diversity.

Other species such as purple starthistle (*Centaurea calcitrapa*) and spotted knapweed (*Centaurea maculosa*) are also significant invaders and have the potential to occupy large areas of California rangeland.

Medusahead (*Taeniatherum asperum*) is a serious threat to rangelands with sparse native plant communities and disturbed areas. This species is an effective competitor against native grasses and forbs and can reach densities of 1000 to 2000 plants per square meter once established. This plant, given its high silica content, is unpalatable to livestock and native wildlife except in the early spring. After dropping their seeds, the plants persist as a dense layer of litter that hinders germination of native species, ties up nutrients, and contributes to fire risk and the rate of fire spread in the summer (Kan and Pollak, 2000). See the document Ecology and Management of Medusahead.

A number of non-native species are prodigious water users and extensive stands of these species reduce water quality and quantity, alter stream hydrology, lower soil water profiles, and displace native riparian plant species. Tamarisk (*Tamarix sp.*) is widely distributed throughout the Mojave and Colorado

deserts, Owens Valley, central and south coasts, and the San Joaquin Valley. This rapidly growing shrub/small tree, when occurring in dense stands reduces stream channel width, and given its high evapotranspiration rate, can lower the water table in riparian areas. Soil salinities are also increased near this plant, which serves to inhibit the germination and growth of native riparian species (Lovich, 2000).

Giant reed (*Arundo donax*) is a perennial grass that grows to 30 feet in height. The species is found in central and southern California river valleys and is increasing in the north coast region. The plant establishes itself via rhizomes or plant fragments carried by moving water. The giant reed is also capable of rapidly expanding beyond the limits of riparian vegetation. It displaces native species by shading and dominating use of available soil moisture. When found in large stands, the species alters hydrological regimes and reduces the availability of groundwater by transpiring large amounts of water from semiarid aquifers (Dudley, 2000). See the document Team Arundo del Norte (California Environmental Resources Evaluation System, 2002).

Tall whitetop or perennial pepperwood (Lepidium latifolium) is a substantial and increasing rangeland problem. Originally a weed associated with irrigated agricultural lands, it has moved into rangelands throughout California, particularly in the northeastern portion of the state. The plant thrives in wet areas and out competes native species use for grazing and wildlife habitat.

Future patterns of exotic species infestation and range expansion are dependent on the rate of new species introduction and establishment, containment success for existing species, and the rate of recovery on lands already occupied by the exotic species. Given both natural and human induced levels of disturbance, it is likely that exotic plant species will continue to be introduced into rangelands suitable for their establishment and/or expansion (Mitchell, 2000).

Management of rangeland plant communities dominated by exotic species

New approaches are needed to manage communities dominated by exotic plant species in order to prevent continued decline of certain native species. For example, introduced plants have extensively altered biological communities in the San Joaquin Valley to the detriment of wildlife and plant species adapted to the open understories of the original desert scrubland. Germano et al. (2001) used state and transition modeling to examine the transition of the original saltbush shrubland of the San Joaquin Valley to the non-native annual grassland that is now dominant. Non-native grasslands in the San Joaquin Valley appear resistant to disturbances and resilient in their ability to maintain a dominant position in the plant community. They concluded that management actions using livestock grazing were necessary on at least an interim basis in order to reduce grass cover and maintain populations of a number of endemic vertebrate species. Without management action, these non-native grasslands will persist, even if the original state was a stable desert scrubland. However, current understandings regarding the habitat requirements of species of concern make the removal of exotic species through the large-scale application of certain management choices (e.g., prescribed burning, chemical or mechanical control, removal of all disturbance) an economic, energetic, and ecological impossibility.

Prevention, public and employee education, and timely control of newly discovered or small exotic plant infestations are considered effective and economical first steps. The process and urgency to control

exotic plants is synonymous with fire management techniques. The strategies of prevention, public education, detection, and rapid control effort are common to both exotic plant and wildland fire control. However, ecological impacts differ. Impacts from exotic plants are usually long-term and permanent (BLM, 1998) while the result of wildland fires is temporary in nature. See the document Partners Against Weeds: An Action Plan for the BLM.

Conifer Woodland expansion into grasslands

Native woody plants have significantly increased in abundance on a number of arid and semiarid grassland steppes and savannas over the past century. They are now found well beyond historic distributions. Change in area of these woodland types, the potential for increased soil erosion associated with land cover change, and the influence on biological diversity and rangeland productivity are useful indicators of rangeland health and sustainability (Mitchell, 2000).

The causes of woodland expansion are both complex and interactive. A number of climatic and human-caused disturbance factors have been attributed to the increase in acreage and canopy cover. These factors include the effects of fire exclusion, overgrazing of livestock, and moister climatic conditions during the last 100 years favoring tree establishment and growth (Miller and Rose, 1999). Portions of California rangelands have not escaped the range expansion of woodland species such as western juniper (*Juniperus occidentalis*), Utah juniper (*Juniperus osteosperma*), and single-leaf pinyon pine (*Pinus monophylla*). These expansions in the eastern and northeastern portions of the State are the result of broad scale change in ecological conditions and land use.

Woodlands dominated by western juniper occur on the Modoc Plateau of northeastern California. Pinyon-juniper woodlands are found on the east side of the Sierra Nevada, south of Kern County. The distribution of each of these woodland types has greatly increased since the late 1800s. It is likely that prior to grazing and fire exclusion efforts much of the pinyon-juniper and juniper woodlands of the Great Basin existed as savannah in which trees were restricted to areas (e.g., rocky outcrops) with limited understory fuel (West, 1984; Miller et al., 1995).

Native woody plants have significantly increased in abundance, affecting soil erosion and influencing biodiversity.

In other areas, perennial grasses historically provided the fine fuel necessary to carry fire at intensities that removed young-age class trees (trees less than 50 years old are particularly susceptible) from the grassland community. Beginning in the mid-1800s, livestock grazing on available perennial grasses removed or broke the continuity of these fine fuels resulting in decreases in both fire size and intensity. Similarly, reduction in Native American populations actively using fire as a management tool also influenced fire frequency. Fire suppression policies have also facilitated juniper encroachment by diminishing the influence of fire on woodland extent (Miller et al., 1995; BLM, 1998).

The understory of juniper woodlands prior to grazing and fire exclusion effects was likely similar to that of the adjoining sagebrush steppe (West, 1988). As juniper density and canopy cover increased over the last 120 years, the diversity of plant species and density of cover in the understory has decreased. Although it is of low vigor and cover, cheatgrass is now the dominant understory grass species. Given

their extensive root systems, capability for shading, and the presence of chemicals within their leaves inhibiting seed germination, junipers have a competitive advantage over other plant species (BLM, 1998). Dense juniper stands are therefore generally devoid of sufficient ground cover to prevent soil erosion and loss. In addition, the lack of understory vegetation makes these sites unsuitable as rangeland supporting domestic livestock and undesirable as wildlife habitat. Soil erosion rates in juniper and pinion-juniper woodlands generally exceed those of the surrounding sagebrush steppe plant community (Evans, 1988; BLM, 1998), and in one Colorado study, pinyon-juniper exhibited erosion rate increases of 400 percent during the last century (Carrara and Carroll, 1979).

Correlating soil loss to a decrease in site productivity is a difficult task in arid and semi-arid environments. Rates of soil formation are slow and information on past land uses, variability in rainfall pattern, and erosional history of a site, which influence recent soil loss rates, are generally not available. Nevertheless, soil represents a principal source of nutrients with concentrations in the humus and litter layers (Doescher et al., 1987) that are vulnerable to wind and water erosion, and management influences. Soil losses exceeding a few millimeters can result in a disproportionate loss of nutrients and ultimately a reduction in site productivity (DeBano, 1991 fide Baker et al., 1995).

Declining aspen stands

Quaking aspen (*Populus tremuloides*) stands have long been recognized for their forage, wildlife habitat, and aesthetic value. Aspen is found as a relatively minor component of the vegetation in the Sierra Nevada growing as scattered groves along riparian zones and on transitional areas between coniferous forests and mountain meadows (Mueggler, 1985). However, these stands provide a variety of values disproportionate to their acreage in the forest and rangeland landscape. These values include livestock forage, wildlife habitat, water yield, esthetics, recreation opportunity, and landscape diversity.

Aspen provide livestock forage, wildlife habitat, water yield, esthetics, recreation opportunity, and landscape diversity.

Aspen dominated sites are also high in biological diversity and marked changes in flora and fauna result when these areas convert to coniferous forest or shrub dominated habitats. Aspen stands in California support 154 terrestrial vertebrate species (CWHR version 7.0), and these stands are an important component of structural diversity on landscapes otherwise dominated by coniferous forest or shrubland. Aspen abundance in the western United States has declined dramatically over the past century, given livestock grazing and fire control practices, as well as wildlife use. A review of aspen data collected by the USFS Forest Inventory and Analysis program suggests that aspen acreage in the western United States has declined by approximately 60 percent since European settlement began (Mitchell, 2000). As fire frequency intervals lengthen, aspen is more likely to disappear from the landscape. Aspen regenerates principally through vegetative means (suckering) and with the absence of fire related disturbance is a less efficient competitor than conifer and shrub/grass species. Overuse of aspen stands by livestock combined with the presence of browsing wildlife species also compound the problem of aspen regeneration.

Livestock and wildlife remove fine fuels, graze on young aspen trees, and break sprouts to gain access to terminal buds (DeByle, 1985). Mitchell (2000) considers it unlikely that the rate of aspen decline can be reversed, given declining public support for applicable silvicultural techniques such as clear cutting, the cost of prescribed fire, and the continuing effects of livestock and wildlife grazing.

In contrast to the Rocky Mountain and Intermountain West, there have been few studies done to assess the status of aspen in the Sierra Nevada. However, Rich et al. (2001) conducted aspen stand condition inventories on the Stanislaus, El Dorado, and Lassen national forests. Their results indicate that the majority of aspen stands examined are subject to the same factors implicated in the decline of aspen in the Rocky Mountains and Intermountain West. Aspen stands that were subject to conifer removal or prescribed fire treatments were largely restored. For those sites that were not successfully regenerated, soil moisture regime changes and livestock browsing were considered most influential on success. The Eldorado National Forest is undertaking an extensive effort to inventory aspen communities and develop baseline-monitoring data to assess change in aspen conditions over time. Of 230 aspen stands examined, 64 percent were classified as having moderate (greater than 25 percent of stand effected) to total conifer encroachment. Sixty-six stands (29 percent) were categorized as even aged being composed of mature trees with a minimum amount of stem suckering present. Of these 66 stands, 41 had moderate to total conifer encroachment. There are a number of indications that cattle grazing can have an extensive effect on aspen suckering and health of the stands (Burton, 2000).

Decline in the acreage and quality of early successional plant communities used by livestock and deer over the last 50 years has likely intensified the competitive interaction of these two species in preferred habitats (Loft et al., 1998). In the absence of livestock, aspen was the most highly preferred habitat for Sierra Nevada mule deer (Loft and Menke, 1988). Similarly, many aspen stands have declined in extent or distribution in northeastern California (Dale, 1996). Decades of season-long grazing access by domestic livestock and changes in fire frequency are also considered the principal causative variables in this region. Aspen stands in these areas generally appear as remnant trees in meadows with sparse or absent regeneration or as mature stands being overgrown by conifers. Few stands show full crowns with a range of age classes for future recruitment (Dale, 1996).

Findings on technological improvements and rangeland management methods

Improving rangeland productive capacity depends on improvements in ecological condition more so than improvements in technology.

Improving rangeland productive capacity depends to a large degree on improvements in ecological condition more than improvements in technology because abiotic factors (precipitation, climate, soil) especially in annual grass dominated types, largely determine the productivity of the land (Heady and Child fide Mitchell, 2000). Ecological improvements critical to range improvements and manifested by range management techniques, include those that mimic natural events, maintain hydrological function and water quality, and control exotic, invasive plants.

Technological advancement

Bioengineered plants are one technological improvement that holds promise. Aspects of the technology relative to range foraging include biological control of exotic, invasive weeds and improvement of the metabolic efficiency of domestic livestock (Persely, 1990 fide Mitchel, 2000a). However, the application of bioengineering technology has focused on high yield applications (crops) and not on marginally economic forage plants associated with rangelands (Hazell and Ranasamy, 1991 fide Mitchell, 2000).

Management practices to promote rangeland health

Ranchers, extension experts, and the USFS are now utilizing several range management techniques designed to promote rangeland health. These include de-emphasizing continuous, season-long grazing and increasing grazing systems such as deferred rotation, early season or late season systems and limited use of riparian habitats (USFS, 2001). Some of the recommended standards used to judge grazing strategies and to maintain healthy rangeland conditions are summarized in the Sierra Nevada Forest Plan Amendment (USFS, 2001):

- limit livestock use to no more that 30 to 50 percent of the grass and forbs during grazing periods;
- limit livestock use to no more than 20 percent of riparian vegetation;
- limit stubble heights and stream bank trampling to maintain cover and capture sediment to support the rebuilding of streambanks;
- minimize streambank disturbance (e.g., trampling) to less than 20 percent;
- de-emphasize intensive grazing systems in favor of limited systems such as rest /rotation and deferred systems; and
- identify rangeland readiness for grazing purposes based on current rainfall and visible plant condition.

Contemporary range management techniques: The California Cattlemen's Association has documented several case examples of contemporary grazing practices that help promote ecological conditions in their publication, "Grazing for Change: Range and Watershed Management Success Stories in California." See the document Grazing for Change. The goals of many of these examples include the following:

- promote sustainable use of natural rangeland condition while operating economically viable grazing operations;
- promote the re-establishment of native species and ecosystems;
- improve riparian systems by promoting habitat for key aquatic species (through debris introduction or exclusion) minimizing erosion hazard problems, and increasing water holding capacity;
- maintain a viable range operation that maintains the multiple values of rangelands;
- increase plant diversity supporting wildlife;
- maintain rare plants; and
- control noxious weeds.

These objectives have been implemented by certain management innovations and tools including the following:

- limit exotic and invasive species, restore native species, create even litter coverage, and reduce cattle trail impacts by using high intensity, short rotation grazing;
- provide off stream water sources by using gravity systems and solar powered pumps, and establish well and water troughs away from riparian areas;
- remove dominant, native species, such as western juniper, encroaching upon riparian areas in order to promote grass and shrub introduction;
- promote plant regeneration through methods such as rest and rotation grazing;
- stabilize stream scour and reduce erosion through the use of riprap, weirs, and grade stabilization structures;
- reduce the effects of manure on water quality by providing sloping areas away from stream courses and using natural filters to stop runoff ;
- reduce hoof impact by constructing riprap in water areas;
- reforest riparian areas to increase water holding capacity;
- locate feeding racks and corral areas away from streams;
- isolate riparian areas using enclosure fences;
- stabilization and engineering of roads;
- incorporate prescribed fire to reduce pasture weeds; and
- monitor rangelands intensively using condition assessment "rules of thumb" (e.g., minimum stubble height) and photo plot comparisons.

Findings on agency specific rangeland assessments

Many empirical measurement methods are well documented to evaluate site-specific rangeland conditions. These methods usually include some physical descriptions of the site and an evaluation of vegetation characteristics and soil exposure (indicators). Rangeland evaluations have traditionally used measures of similarity and trend. This concept is based on the premise that vegetation succession proceeds in a more or less orderly and linear fashion. Similarity is frequently expressed as an index of where the current plant community is in relation to the historic climax plant community (Potential Natural Community (PNC)). Examples are early, mid, and late successional stages and are used to categorize the quantity and cover provided by characteristic species relative to the potential of the site. In other words, a rangeland site categorized as an early successional stage may be either an excellent or poor example of an early successional stage when considering plant community species composition and productivity and the categorization in and of itself does not suggest a degraded rangeland condition. Indeed, the PNC may well not be the most productive or desirable rangeland condition.

Trend information also provides an important component of the condition evaluation and is an expression of the direction of change in the current plant community relative to PNC. It addresses the question of whether or not change in species composition of the current plant community and associated soils are moving toward or away from PNC or, depending on management objectives, some other desired plant community. The vigor and reproduction of both desirable and undesirable plant species and soil condition are key in determining trend (e.g., improving, static, or decreasing) and correctness of current grazing practices.

Non-federal rangeland assessments

The basic source of information on the condition of non-federal rangelands in California is the 1982 NRI published by the USDA Soil Conservation Service, now the NRCS. However, trends cannot be assessed because data was not collected in California during 1992. The 1982 NRI evaluated range condition based on traditional condition and trend methodologies where species composition, estimated by biomass, is compared to a typical “climax” PNC plant community.

Of the approximately 17 million acres of non-federal rangeland in California in 1982, 11 million acres were annual grasslands and more than five million acres were on sites for which no condition guides had been written. Of the 1.6 million acres that were surveyed in 1982, the majority (60 percent) of non-federal lands were in fair to poor condition (Mitchell, 2000) when evaluated against biomass level of the climax, steady state PNC. The general lack of comprehensive rangeland condition assessment information on private rangelands is a highlighted finding requiring attention in the future.

Condition of federal rangelands

U.S. Bureau of Land Management

The U.S. Bureau of Land Management (BLM) inventories its rangelands and classifies them according to four ecological status categories: PNC (Kuchler, 1964), Late seral, Mid seral, and Early seral. These categories express percentage of similarity between the present vegetation and the PNC as follows: PNC = 76 to 100 percent; Late seral = 51 to 75 percent; Mid seral = 26 to 50 percent; and Early seral = zero to 25 percent (Table 14) (BLM, 1997 fide Mitchell, 2000). Most BLM lands (74 percent) have been classified as either Late seral or Mid seral and have slightly declining trends of total area in these condition categories.

Table 14. Rangeland ecological condition status categories for BLM land expressed as a percentage of similarity of potential natural community species structure based on biomass, 1986-2001

Lands	PNC	Late Seral	Mid Seral	Early Seral
1986	1	44	43	10
1996	3	40	37	15
2001	2	38	38	16

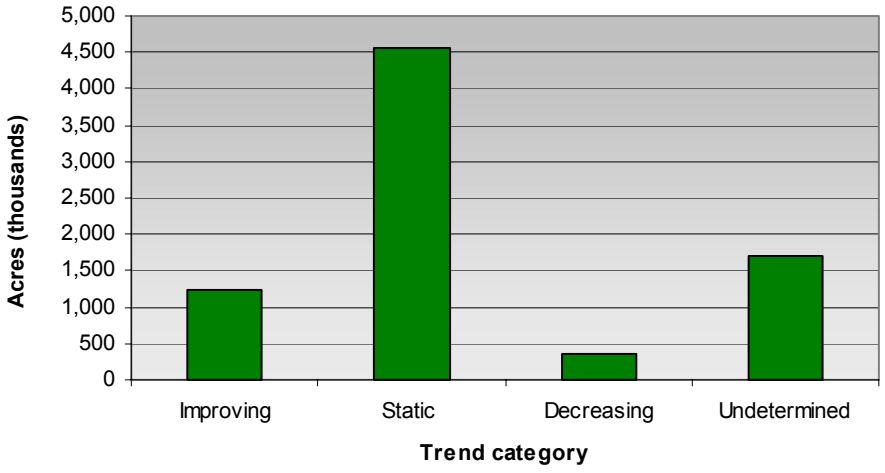
PNC – potential natural community

Excludes unclassified lands

Source: Mitchell, 2000

BLM rangeland condition trends are predominately static or improving (Figure 16).

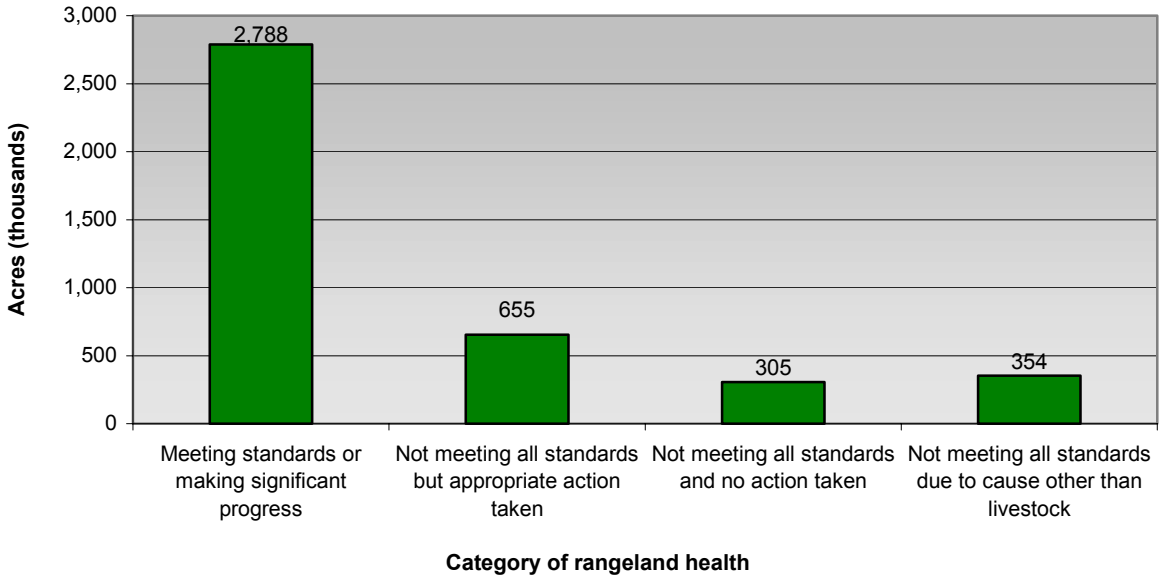
Figure 16. BLM California rangeland trends, apparent and monitored, 2001



Source: Willoughby, 2002

The majority of BLM rangelands meet existing standards of rangeland health (Figure 17).

Figure 17. Distribution of BLM California rangeland by standards of rangeland health, 1998-2001



Source: Willoughby, 2002

U.S. Forest Service

The U.S. Forest Service (USFS) currently does not publish summaries of range condition. Rather, agency personnel use the following descriptions to characterize areas of upland and riparian rangeland vegetation found in grazing allotments:

- meet established Forest Plan Management Objectives (FPMOs);
- progressing toward established FPMOs; and
- neither meet nor are progressing toward established FPMOs.

Categorizing rangeland health in terms of FPMOs can be problematic since most national forests operate under plans approved in the 1980s, and elements from these plans that correspond to rangeland condition do not compare well with trend indicators considered relevant by today's standards (Mitchell, 2000).

While 68 percent of surveyed U.S. Forest Service range allotments meet Forest Plan Management Objectives, there has been little change in this percentage over recent years.

Approximately 50 percent of the total range area had either verified or estimated condition assessments. Of this area (3.6 million acres), approximately 68 percent meet FPMO, 27 percent are moving towards the objectives, and 5 percent do not meet FPMO (Table 15).

From 1995 through 1997, California upland rangelands administered by the USFS showed little change in the number of acres that satisfy FPMO. The USFS suggests that this may be due to the low level of funding for vegetation and grazing management programs supporting National Forest System

rangelands in recent years. Funding throughout the 1990s was just sufficient to cover administrative costs for grazing programs. In general, the only funds used by the USFS for on-site rangeland improvements were those collected from grazing fees (Mitchell, 2000).

Table 15. Area of upland range vegetation within grazing allotments on National Forest System lands in relation to FPMO, Pacific Southwest Region, California (thousands of acres)

	1995	1996	1997
Land category			
Total range vegetation	7,055	6,775	7,121
Having range vegetation management objectives	7,055	6,760	7,106
Monitored during current year	1,806	1,784	1,626
Condition assessment category			
Verified meeting FPMO	809	855	841
Estimated meeting FPMO	1,682	1,641	1,650
Total	2,491 (67%)	2,496 (67%)	2,491 (68%)
Verified moving toward FPMO	250	261	243
Estimated moving toward FPMO	786	788	737
Total	1, 036 (28%)	1,049 (28%)	980 (27%)
Verified not meeting or moving toward FPMO	28	27	28
Estimated not meeting or moving toward FPMO	178	178	139
Total	206 (5%)	205 (5%)	167 (5%)
Undetermined status	3,322	3,025	3,483

Source: Mitchell, 2000

Riparian areas

Over one-third of the riparian areas measured on U.S. Bureau of Land Management lands in California show their natural function to be either at risk or not functioning.

Both the BLM and the USFS in California have focused on the condition of rangeland riparian areas. In March 1996, the USFS and BLM, in cooperation with the NRCS (formerly Soil Conservation Service), initiated a joint strategy to speed cooperative riparian restoration and management. The approach reflected the notion that restoration and management is best addressed at the watershed level and should involve all landowners. To spearhead the effort, a National Riparian Service Team was formed. The team's purpose was to act as a catalyst, providing training and technology transfer, consulting and advisory services, and program review related to riparian restoration.

The Proper Functioning Condition (PFC) assessment was selected as a foundational tool helping people of diverse backgrounds focus on the natural function of riparian/wetland areas rather than benefits received from these habitats (such as recreation, forage, etc.). In order to assess whether or not a riparian/wetland area is properly functioning, this method relied on a qualitative checklist (supported by quantitative sampling) when evaluating vegetation, landform, and hydrological conditions.

The on-the-ground condition, or PFC, refers to how well the physical processes are functioning. The PFC assessment is designed to determine four defined states: PFC, Functional-at-Risk, Nonfunctional,

and Unknown. PFC defines a state of resiliency that allows a riparian/wetland area to hold together during moderately high flow events, thus sustaining that system's ability to produce both physical and biological values. A riparian/wetland is classified as PFC when adequate vegetation, land form, and/or large woody debris is present to support the following processes: 1) dissipate energy, 2) filter sediment, 3) develop root mass for erosion prevention, and 4) create pool or other habitat features supporting biodiversity. PFC does not automatically indicate a desired (future) condition but is always a prerequisite to achieving a desired condition (Mitchell, 2000).

In 1997, 61 percent of BLM riparian areas in California were classified as PFC (Table 16).

Table 16. Status of riparian areas on California BLM lands using the PFC assessment, 1997

PFC		Functioning-at-Risk		Nonfunctional	
Miles	percent	Miles	percent	Miles	percent
1750	61	1023	36	87	3

PFC – Proper Functioning Condition

Source: Mitchell, 2000; Barrett et al., 1995

Information on riparian area condition status is not summarized specifically for USFS lands in California. However, assessment results for all Pacific Coast states show that about 10 percent is neither meeting nor moving towards FPMOs (Mitchell, 2000).

Findings on condition assessment methodologies

In recent years there has been significant conceptual advancement in how rangeland condition and health is best measured and assessed. Applied ecological disciplines, such as forest and rangeland management, are organized around ecological process models that predict the consequences of natural disturbances and/or management activities. In California's range ecosystems, particularly in semi-arid environments, the abiotic environment often dominates and masks interactions and effects of the biotic elements.

Abiotic environmental factors (e.g., soil type and rainfall) and single disturbance events due to weather, fire, and grazing, often dominate resultant range conditions.

Most of California's rangelands exhibit strongly seasonal and irregular rainfall patterns that drive germination, floristic composition and forage biomass accumulation. This dominance of the biotic by the abiotic reduces opportunities for application of the traditional succession model to predict range dynamics. Single disturbance events due to weather, fire, grazing, or management, or combinations of such events can change rangelands in ways that are not consistent with the traditional range succession model. Model failure hinders not only the research and predictive capability of range science but also progress toward sustainable management. When substantial reductions in stocking rates fail to produce the results announced by the theory, the most common management response is to reject any further scientific advice. Similarly, when rangeland are rated in poor condition because they are dominated by exotic species, the public wrongly assumes that they are continuing to deteriorate and that further reduction or removal of livestock will improve the situation.

Traditional indicators of rangeland condition and health, as described above, have dealt with descriptions of rangeland vegetation successional stage. Westoby et al. (1989) proposed state and transition models as an alternative to the traditional range successional stage management model. State and transition models provide a framework to abstract and summarize knowledge about range dynamics and are a promising way to synthesize our understanding of many of California's plant communities. However, a functional approach is needed for models to be of practical use. Because they are more realistic and better able to describe ecosystem dynamics and management interactions, state and transition models have the potential to improve communication between scientists, planners, land managers and the public. Unlike the range succession model, state and transition models do not require specific assumptions except for the idea that ecosystems can have multiple stable states. For example, a given rangeland could be described with a greater or a lesser number of states and transitions, depending on the type and goals of management and on the amount of existing knowledge.

State and transition models recognize that ecosystems can have multiple stable states allowing combinations of plant species to fluctuate over time, and focus on ecosystem function rather than plant community.

The transitions between states may be caused by natural disturbances (e.g., weather, fire, herbivory) or by management actions (e.g., grazing, burning, wood harvest, elimination or introduction of plant species, fertilization). Very often, a particular combination of both types of causes is needed to trigger a transition. Transitions may occur rapidly (fire) or over a period of many years (woody plant recruitment). However, in either case, the rangeland vegetation has crossed a threshold and cannot persist halfway through a transition. For complete information on state and transition rangeland assessment models, see Rangeland Assessment Models. These changes are demonstrated by the invasion of non-native plants, the encroachment of juniper woodlands into grasslands, and the decline in aspen stands.

Bioregional planning, assessment, and monitoring of natural resources are improved with a prediction of vegetation spatial pattern at the landscape scale. Understanding vegetation factors and processes is a prerequisite to predict future patterns of vegetation in landscapes. Toward that end, there is renewed interest in implementing models of vegetation dynamics to assess the effect of human activities on ecosystems and help manage landscapes. Scientists and land managers increasingly use these concepts as a foundation for the development of models of vegetation dynamics that incorporate multiple successional pathways, steady states, thresholds of change, and discontinuous and irreversible transitions (Laycock, 1991; Plant et al., 1999).

In 1994, the Committee on Rangeland Classification proposed that non-equilibrium, state and transition models of succession that focus on ecosystem function rather than plant community composition form the basis for assessing rangeland condition. Principal assessment criteria suggested by

the Committee include soil stability and watershed function, nutrient cycling and energy flow, and recovery mechanisms. Similarly, the Society for Range Management defined sustainability in terms of the maintenance of soil productivity. Soil loss must not reduce the productive potential for a site (Task Group on Unity in Concepts and Terminology, 1995). Although progress is being made, the scientific advances that support state and transition modeling have not been incorporated into national data sets of rangeland condition. Nor are these data sets standardized to allow comparison of conditions across land and resource management agencies (Mitchell, 2000).

Glossary

abiotic: Refers to nonliving objects, substances or processes.

allotment: An area designated for the use of a prescribed number of livestock.

animal unit month: The amount of forage needed by an "animal unit" (AU) grazing for one month. The animal unit in turn is defined as one mature 1,000-pound cow and calf.

annual: Living or growing for only one year or season.

AUM: See **animal unit month**.

biotic: Having to do with living things. Something that is caused by or produced by living things. Having to do with the biological aspects of an environment (as opposed to geological, etc. aspect).

BLM: U.S. Bureau of Land Management.

browse: To feed on leaves, young shoots, and other vegetation.

California Wildlife Habitat Relationship: California Wildlife Habitat Relationship is a state-of-the-art classification system for California's wildlife. CWHR contains life history, management, and habitat relationships information on 675 species of amphibians, reptiles, birds, and mammals known to occur in the State. CWHR products are available for purchase by anyone interested in understanding, conserving, and managing California's wildlife.

carrying capacity: The maximum population of a given organism that a particular environment or habitat can sustain; implies continuing yield without environmental damage. The carrying capacity changes over time according to the abundance of predators and resources (food and habitat).

CDCA: California Desert Conservation Area.

CWHR: See **California Wildlife Habitat Relationship**.

deferred system: A grazing management practice where there is a discontinuousness of the grazing by livestock on an area for a specified period of time during the growing season.

development: A human settlement pattern having a density of more than one housing unit per 20 acres.

early range condition: Forage conditions during the early season grazing period.

early season system: A livestock grazing regime where livestock are grazed in late winter to the spring season.

EPA: U.S. Environmental Protection Agency.

ERS: Economic Research Service.

evapotranspiration: Loss of water by evaporation from the soil and transpiration from plants.

evenaged: A forest stand or forest type in which relatively small (10-20 year) age differences exist between individual trees. Evenaged stands are often the result of fire, or a harvesting method such as clearcutting or the shelterwood method.

exclosure: An area of land enclosed by a barrier, such as a fence, to protect vegetation and prevent grazing by animals.

exotic plant: An introduced plant (not native to the United States) that has the potential to disrupt or change the plant or animal species composition of a native plant ecosystem.

exotics: See **exotic plant**.

fire return interval: A fire record based estimate of the number of years required to burn most or all of the area under consideration, usually based on individual points or small area records of fire occurrence over discrete periods of time. FRI is consequently often used when conducting fire history studies from fire scar records on trees.

FLMMP: Farmland Mapping and Monitoring Program.

forage: All browse and herbage that is available and acceptable to grazing animals.

The Forest and Rangeland Renewable Resources Planning Act of 1974: Requires the Secretary of Agriculture to conduct an assessment of the nation's renewable resources every 10 years. The original act had four requirements for the Assessment: (1) an analysis of present and anticipated uses, demand for and supply of the renewable resources, with consideration of the international resource situation, and an emphasis of pertinent supply and demand and price relationship trends; (2) an inventory of present and potential renewable resources, and an evaluation of opportunities for improving their yield of tangible and intangible services; (3) a description of Forest Service programs and responsibilities; and (4) a discussion of important policy considerations, laws, regulations, and other factors expected to influence and affect significantly the use, ownership, and management of forest, range, and other associated lands.

Forest Plan Management Objective: Long-term direction as legally mandated by U.S. Forest Service land management plans.

FPMO: See **Forest Plan Management Objective**.

FRAP: Fire and Resource Assessment Program.

FWS: U.S. Fish and Wildlife Service.

grazed forest: Lands used for grazing livestock with at least 10 percent tree cover.

grazing capacity: Maximum stocking rate possible without damage to vegetation or related resources.

grazing land: Rangelands that are usable for livestock grazing and that display periodic use.

grazing permit: Land lease offering written permission to graze a specific number, kind, and class of livestock for a specified defined allotment.

herbaceous: Refers to a plant that has a non-woody stem such as forbs, grasses and ferns.

herbivory: The consumption of herbaceous vegetation.

humus: Leaves and litter that have begun to decompose. The part of dirt or soil which comes from organic matter, such as from dead and decaying plants and animal remains.

IHRMP: Integrated Hardwood Range Management Program.

important farmland: A land suitability category used by the California Department of Conservation FLMMP that classifies land suitable for agricultural production based on physical and chemical soil characteristics or actual use.

intermountain: Located between mountains or mountain systems, especially lying between the Rocky Mountains and the Sierra Nevada or Cascade Range in the western United States.

land cover: Predominant vegetation life forms, natural features, or land uses that occupy a land area.

LCMMP: Land Cover Mapping and Monitoring Program.

litter: The uppermost layer of the forest floor consisting chiefly of fallen leaves and other decaying organic matter.

management landscape class: A conceptual framework developed by FRAP which classifies lands based on the primary land use objective, ownership status, and population density.

management landscape map: Depicts the geographic distribution of land use objectives, ownership, and population density.

Montreal Process: A scientifically rigorous set of criteria and indicators used to measure forest management and sustainability.

multiple successional pathways: The ordinary process of change in a plant community.

nonpoint: Pollution whose source cannot be ascertained including runoff from storm water and agricultural, range, and forestry operations, as well as dust and air pollution that contaminate waterbodies.

NPS: National Park Service.

NRCS: U.S. Natural Resources Conservation Service.

NRI: National Resource Inventory.

overstory: The larger, taller trees that occupy a forest area and shade young trees, hardwoods, brush, and other deciduous varieties growing beneath the larger trees (i.e., understory).

pasture: A land cover or use category of land managed primarily for the production of introduced forage plants for livestock. May consist of single species, agri-mixtures, or grass-legume mixture. Management usually consists of culture treatment including fertilization, weed control or reseeding.

perennial: A plant which lives or continues over two years, whether it retains its leaves in winter or not.

PFC: See **Proper Functioning Condition**.

PNC: See **potential natural community**.

potential natural community: The biotic community that would be established if all successional sequences of its ecosystem were completed under present environmental conditions without additional human-caused disturbance. Grazing by native fauna and natural disturbances, such as drought, floods, fire, insects, and disease, are inherent in the development of potential natural communities, which may include naturalized exotic species.

primary rangeland: Lands with vegetation types considered to be most important to livestock grazing.

productive capacity: The ability of an ecosystem to produce the raw materials necessary for economic activities. These materials include all renewable resources found both on and below the surface of the ecosystem such as agricultural products, fibers, foodstuffs, timber, water, etc.

Proper Functioning Condition: Defines how well the physical processes are functioning. The PFC assessment is designed to determine four defined states: proper functioning condition, functional-at risk, nonfunctional, and unknown. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during moderately high flow events, sustaining that system's ability to produce values related to both physical and biological attributes.

rangeland: Any expanse of land not fertilized, cultivated or irrigated that is suitable, and predominately used for, grazing by domestic livestock and wildlife. These include the Conifer Woodland, Hardwood Woodland, Shrub, Grassland, Desert, land cover types along with some habitats within the Wetland and Hardwood Forest land cover classes.

RDM: See **residual dry matter**.

regime: The condition of a river with respect to the rate of its flow, as measured by the volume of water passing different cross-sections in a given time, uniform regime being the condition when the flow is equal and uniform at all the cross sections.

residual dry matter: The amount of dry plant material left on the ground from the previous year's growth.

rest-rotation grazing: A system in which one part of the range is ungrazed for an entire grazing year or longer, while other parts are grazed for a portion, or perhaps all, of a growing season.

rhizomes: A horizontal, usually underground stem that often sends out roots and shoots from its nodes.

rill: A very small brook; a streamlet.

riparian: Relating to or located on the banks of a river or stream.

riparian area: Transition zone between a stream's edge and the dryer uplands.

riprap: A loose assemblage of broken stones erected in water or on soft ground as a foundation.

RPA: See **The Forest and Rangeland Renewable Resources Planning Act of 1974**.

RWQMP: Rangeland Water Quality Management Plan.

sheet: An extensive bed of an eruptive rock intruded between, or overlying, other strata.

silviculture: Generally, the science and art of cultivating (such as with growing and tending) forest crops, based on the knowledge of silvics. More explicitly, silviculture is the theory and practice of controlling the establishment, composition, constitution, and growth of forests.

species of concern: Flora and fauna officially designated by federal or state agencies as threatened, endangered, sensitive, or rare.

stable climax plant community: A plant community that is resistant to change.

state and transition models: A range vegetation assessment model where ecosystem dynamics (such as fire and weather) or management actions are used to evaluate range conditions.

steady state: A range condition assessment class where both vegetation type and composition and structure are not likely to change without management action.

stocking rate: The relationship between the number of animals and the grazing management unit utilized over a specified time period. May be expressed as animal units or forage intake units per unit of land area (animal units over a described time period/area of land).

succession: Process of vegetational development whereby an area becomes successively occupied by different plant communities of higher ecological order.

successional stage: A particular state of ecological development.

SWRCB: California State Water Resources Control Board.

TMDL: See **Total Maximum Daily Load**.

Total Maximum Daily Load: A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, as well as an estimation of the percentage originating from each pollution source. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for State-designated purposes. The calculation must also account for seasonal variation in water quality.

understory: The trees and other woody species growing under a relatively continuous cover of branches and foliage formed by the overstory trees.

USDA: U.S. Department of Agriculture.

USFS: U.S. Forest Service.

vegetation response: The resultant change in vegetation type, composition and structure following management treatment or a natural event.

vegetation succession descriptions: Range condition evaluations based on the ecological change in plant communities.

watershed: The land area drained by a particular stream course.

weirs: A fence or wattle placed in a stream to catch or retain fish.

woody plant: A plant having hard lignified tissues or woody parts especially stems.

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